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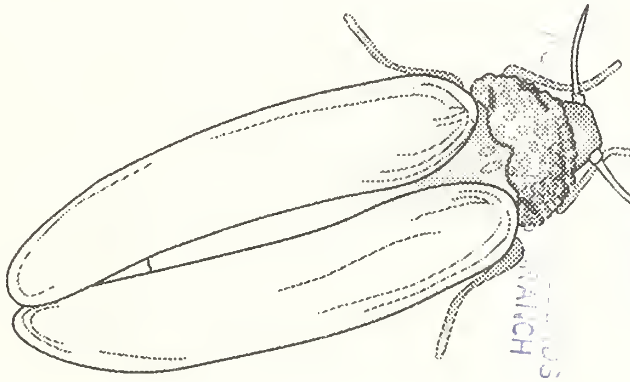
Sweetpotato Whitefly: 1993 Supplement to the Five-Year National Research and Action Plan

First Annual Review Held in Tempe, Arizona January 18–21, 1993

In cooperation with—
USDA/Cooperative State Research Service and the State Agricultural Experiment Stations
USDA/Animal and Plant Health Inspection Service
USDA/Extension Service



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I. Editors' Comments

The enclosed compilation of more than 100 abstract reports of research progress is a remarkable testimony to the combined efforts of research, regulatory, state experiment station and agricultural industries cooperative effort to provide immediate, and long-term solutions to management of the sweetpotato whitefly. We appreciate the response, contributions and participation of all those attending and/or providing information incorporated in this publication.

The abstract contents remain the sole responsibility of the authors. Other sections of this publication are the combined effort of the meeting participants with minor editing to conform to camera-ready format requirements.

Editors: T. J. Henneberry, N. C. Toscano, R. M. Faust and J. R. Coppedge

II. PROGRESS REVIEW ORGANIZATIONAL TEAM

USDA Sweetpotato Whitefly Research, Education and Action Coordinating Group

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Acknowledgment:

The National Coordinators, Program Chairmen, and Technical Committees sincerely appreciate the contributions of all the participants. We especially appreciate the efforts of M. Reega, L. Jech, D. Guerra and D. Shoemaker for their help in local arrangements.

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IV. FOREWORD

The Agricultural Research Service with the cooperative efforts of the Animal and Plant Health Inspection Service, Cooperative State Research Service, Cooperative Extension Service, State Agricultural Experiment Stations and representatives of the cotton, vegetable, ornamental and nursery industries convened a series of three meetings during 1991 and 1992 in response to the serious nature of the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), problem in agricultural crop production systems.

The purpose of the meetings was to develop cooperative research and team efforts, interagency and national in scope, to develop effective, economically and socially acceptable methods of managing sweetpotato whitefly populations. Inherent within the nature of these cooperative efforts were the benefits of communication, exchange of ideas, optimization of the use of resources, priority setting and the establishment of annual reviews of progress to reassess the problem, identify research areas with a high probability of success, and evaluate the effectiveness of research and action agency efforts.

The meetings held October 24-25, 1991 in Atlanta, GA, December 12-13, 1991 in Reno, NV, and February 18-21, 1992 in Houston, TX culminated in a comprehensive conference report and 5-Year National Research and Action Plan for Development of Management and Control Methodology for the Sweetpotato Whitefly. The 5-year research and action plan clearly establishes annual goals and objectives within the highest priority research areas of (1) Ecology, Population Dynamics and Dispersal, (2) Fundamental Research-Behavior, Biochemistry, Biotypes, Morphology, Physiology, Systematics, Virus Diseases, and Virus-Vector Interactions, (3) Chemical Control, Biorationals, and Pesticide Application Technology, (4) Biological Control, (5) Crop Management Systems and Host Plant Resistance, and (6) Integrated Techniques, Approaches, and Philosophies.

The war between the agricultural community and the sweetpotato whitefly (SPW) continues, but we have made a number of significant gains and advances over the past year in all of the six major research and action areas since the implementation of the 5-year National Research and Action Plan for Development of Management and Control Methodology for the Sweetpotato Whitefly. Progress is summarized in this first annual review report of the Research and Action Plan and is the collective result of an intense team effort. The multifaceted approach being used in this team effort will be of great advantage since the technologies being generated should give the agricultural industry the ability to shift and combine control measures faster than this pest can adapt through mutation and natural selection.

On September 9, 1992, at a meeting of an interagency SPW *ad hoc* working group held in Washington, D.C., a recommendation was made to the Office of the Secretary, USDA, that a USDA Sweetpotato Whitefly Research, Education and Action Coordinating Group be formed for the purpose of helping to unify interagency activities. The first organizational meeting of the Coordinating Group was held on November 20, 1992, in Washington, D.C. The Coordinating Group is composed of principal members from each of the Services and the SAES (two members from ARS, two members from APHIS, two members representing CSRS/SAES, and one member from ES. Currently, the ARS serves as the Chair of the Coordinating Group.

To aid the goals of the National Research and Action Plan, this Interagency Group is charged with focusing the USDA Interagency and partner State Agricultural Experiment Station resources on the SPW and providing a mechanism for coordination for research, education, and implementation to effectively manage this pest. The Coordinating Group will also monitor the progress of Service and SAES programs; keep the Services and SAES apprised of progress, coordinate review, and facilitate the evaluation of relevant information generated under the program; help set priorities; maximize use of resources and provide appropriate rationale to justify increased resources; and help in synthesizing and implementing deliberations, advice,

and recommendations of the Interagency Sweetpotato Whitefly Technical Working Group. Commodity groups and industry are expected to be a part of the process.

Members of the Coordinating Group express deep appreciation to all of the individuals who have made contributions to this progress review report. Special appreciation is accorded to Drs. T. J. Henneberry and N. C. Toscano, Annual Review Program Co-Chairs and their staffs, to the SPW Technical Committee, to the National Coordinators, and to the Program Chairs for their substantial efforts in this process.

Robert M. Faust
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ARS National Program Staff
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V. EXECUTIVE SUMMARY

The coordinated effort to formulate the 5-Year National Research and Action Plan for Development of Management and Control Methodology for the Sweetpotato Whitefly (SPW) involved about 300 individuals representing USDA agencies (ARS, APHIS, CSRS, and CES), State Agricultural Experiment Stations and the commodity industries. The need for such a plan was based on the epidemic outbreaks of the SPW in California, Arizona, Texas and Florida, resulting in conservative estimates of losses in the agricultural communities involved that exceeded $200 million. Infestations in 1992 on cotton and numerous ornamental crops in the San Joaquin Valley, CA, as well as local and variable infestations in Georgia and other states suggest that the full extent of the problem may not yet be realized.

The development and implementation of a national plan to optimize research progress and maximize return on resources was timely to fulfil the needs of the scientific and agricultural communities. Cooperative, complimentary research programs, open lines of communication, frequent information exchange and optimum utilization of resources were stressed as the cornerstones of the national program. The enthusiastic responsiveness and participation of growers, agricultural industries and the scientific community suggest that the concept is fully accepted and a major asset in progressive development of strategies that provide solutions to the SPW problem.

The results of the first annual progress review show substantial progress in all of the national plan's priority areas. Over 100 abstracts of ongoing research show the extensive national effort being expended to provide immediate and short-term relief from losses as a result of the SPW. But more importantly, the developing basic and fundamental information on natural enemies, biology, virus-vector relationships, host plant interactions and population dynamics will provide a firm base for the development of efficient long-term and acceptable strategies to manage SPW populations. A major effort must be made to resolve the biotype-species nomenclatural issue and address the ramifications of the existence of a new species if so indicated.

The coordinated national testing program to evaluate chemical and biorational approaches on key cultivated crops identified several materials alone or in combination that show promise for controlling SPW using conventional approaches. Continuing research to refine rates, frequency and timing of application is essential to determine the role of chemical control as a component of overall management systems. Further, the excellent progress made in developing insecticide resistance management must be considered a vital part of chemical control approaches for SPW. Carefully developed chemical control rotational systems will help to assure maximum longevity of materials used in management programs.

Biological control initiatives to provide baselines on the role of indigenous natural enemies, microbials with control potential, and natural factors in regulating SPW populations, as well as collection, identification,

importation and characterization of exotic biological materials have been particularly rewarding. The information being developed is providing a sound basis for identification of key natural enemies for focus in augmentation and conservation programs. Further, the impressive list of more than 25 exotic strains and new natural enemy species that have potential usefulness in release, establishment and evaluation programs demonstrates exciting progress that may lead to effective population regulation components in overall areawide management strategies.

Finally, the broad scope of research investigating behavior, biochemistry, physiology, morphology and systematics is providing significant information that is contributing to development of long-term economic and socially acceptable integrated pest management strategies with an ecological base.

A major consideration and area of concern for the future of the national program is maintaining a continuing level of effort in the identified high priority research with the current constant level of financial and manpower resources. Most of the initial research effort has indicated positive and potentially useful results that need additional funding for expansion and exploitation. This can only be accomplished, within constant funding levels, by reassessment of priorities and redirections of resources into those areas that have the highest probability of success. This approach necessitates a calculated risk that some high priority research will be neglected.

VI. ANNUAL REVIEW OBJECTIVES

The National 5-Year Research and Action Plan provides direction and research implementation for a coordinated, cooperative effort by the agricultural community to provide short and long-term solutions leading to the development of sweetpotato whitefly management systems. The objectives of the annual review process are to (1) provide a forum for exchange of research information and ideas, (2) plan cooperative work, and (3) evaluate research progress in relation to goals, objectives and priorities. The review process should additionally identify areas where research is lacking and provide the framework for recommendations for (1) reassigning or deleting existing priorities, (2) adding additional priorities, (3) making other adjustments in the plan that may be necessary to accommodate the research effort within the constraints of available resources, and (4) planning the most efficient and productive use of additional funds that may become available to the research and action communities.

VII. CURRENT STATUS OF THE SWEETPOTATO WHITEFLY PROBLEM

The sweetpotato whitefly continues to be a worldwide pest of cotton, cultivated food and ornamental crops. The results of a recent survey found that 16 of 27 cotton-producing countries throughout the world reported sweetpotato whitefly as a major economic pest during mid- to late periods of the cotton growing seasons. The sweetpotato whitefly was described from tobacco in Greece about 1889, recorded from sweetpotato plants in Florida in 1894, from cotton in Arizona in 1926 and California in 1928, weeds and cotton in 1946 and 1959, respectively, in Texas, and sweetpotatos in Georgia in 1950. Even with these long associations within diverse plant habitats across the U.S. cotton belt, SPW rarely developed economic infestation levels. Studies in California cotton from 1962-1965 suggested that in most cases economic damage occurred in association with extensive insecticide use patterns. The increasing magnitude of the problem in cotton in Arizona and California beginning in the 1980's remains unexplained. Similarly, high sweetpotato whitefly populations were not recorded in Florida until 1986 under greenhouse conditions followed by widespread infestations in field-grown tomatoes during 1987 to 1988. Epidemic sweetpotato whitefly outbreaks occurred on cotton in Texas in 1988, also under unknown circumstances. Sweetpotato whitefly infestations on cotton have been reported in New Mexico and Georgia and in 1992 from numerous locations in the San Joaquin Valley, CA. Damaging populations now occur on tomatoes, cole crops, cucurbits, alfalfa and

many household ornamental plant species as well as in commercial greenhouses in the Northeastern United States.

Explanations for increasing sweetpotato whitefly populations, not only in the United States but worldwide, have been varied and suggest a wide divergence of opinion. Outbreaks reaching epidemic populations in Southern California and parts of Arizona in the early 1980's were followed by several warm winters that may have encouraged invasion and adaptation to more northerly habitats or more simply, were associated with increased SPW survival in relation to higher populations of frost-susceptible weeds. The increasing populations also increased with the coincidental increase in the use of pyrethroid insecticides, proposed adverse effects on natural enemies, and the demonstrated development of SPW insecticide resistance. In other parts of the world, similar explanations have been offered for the increasing magnitude of the problem, as well as less competition for sweetpotato whitefly as a result of the effective control of other insects, changing crop production practices, and effects of insecticides alone or on cotton-plant physiology resulting in increased sweetpotato whitefly fecundity.

Conservative estimates for the 1991 growing season suggested direct dollar losses exceeding $200 million nationwide. The Florida tomato industry reported $30 million damage from tomato early ripening in 1988, the Rio Grande Valley of Texas $80 million losses to cotton and more than $20 million losses to fruit and vegetables in 1991. California and Arizona losses from all affected cultivated crops exceeded $100 million in 1991. Total assessments for the 1992 growing season situation have not been accumulated, but preliminary reports attribute SPW damage losses to cotton alone in Arizona exceeding $100 million. Reduced acreages of cotton, melon and other vegetable crops in the Imperial Valley of California have occurred.

The nomenclature and classical taxonomic relationships of sweetpotato whitefly which have been confused for many years remain frustrating. The sweetpotato whitefly has been referred to in the literature as the cassava whitefly, tobacco whitefly, poinsettia whitefly, and cotton whitefly, as well as *B. tabaci*. The taxonomic relationships and the synonymy of the species have been reviewed on several occasions. Taxonomic confusion has arisen because of the variation in several morphological characters as well as the sweetpotato whitefly varied host plant associations and the effect of host plants on morphological characteristics. Further, sweetpotato whitefly race and/or biotype designations have often been recorded in past literature in relation to host affinities and virus transmission vector interactions. The possibility of biotype occurrence has received new interest with the increasing importance of sweetpotato whitefly in crop production on a worldwide basis. The detection of differences in electrophoretic isozyme patterns, biology and extended host range have provided evidence for the existence of different biotypes as compared to sweetpotato whitefly previously encountered in the desert Southwestern United States crop production areas. The possibility that a new species is involved is also being considered. Clarification of SPW systematics, using classical and new methodologies of morphology, enzyme characterization, DNA analysis, behavior, biology, and other appropriate techniques may clarify the nomenclatural confusion.

Taxonomic clarification, as well as the development of effective, efficient control methodology that is socially and environmentally acceptable must remain high research priorities in the agricultural communities affected.

T. J. Henneberry and N. C. Toscano
Co-Chairs

VIII. REPORTS OF RESEARCH PROGRESS

A. Ecology, Population Dynamics, and Dispersal

Chairs: Steve E. Naranjo and Harold Browning

Committee Members: G. Nuessly, D. Byrne, T. Perring, M. Parella, and H. Costa

1. Abstracts
2. Table A
3. Research Summary

INVESTIGATOR'S NAME (S): D. H. Akey[1], T. J. Henneberry[1] and M. Hernández[2]

AFFILIATION & LOCATION: [1] USDA, ARS, Western Cotton Res. Lab., Phoenix, 85040, and[2] Co-chairman for International Cotton Pest Work Committee, Mexicali, Mexico

RESEARCH & IMPLEMENTATION AREA: Section A, Ecology, Population Dynamics and Dispersal

DATES COVERED BY REPORTS: July, 1992

SPW movement into cotton from cantaloupe or squash was studied by 1) noting the condition of the primary (infested) host plant, 2) recording the number of adults per leaf (5th leaf/leaf branch, N=5) from the plant terminal of the cantaloupe or squash and 3) recording the numbers of adults on adjacent cotton(5th leaf down from terminal) at intervals of 1-10, 20, and 50 meters from the cantaloupe or squash. The first study was done at 5 of 10 sites in Sonora, Mexico between Mexicali and San Luis and observation were made in a single straight line perpendicular to the rows of cotton. The second study was done at the USDA,ARS Western Cotton Research Laboratory, Phoenix with cantaloupe planted in a cotton field. Adult SPW counts were taken at each of the 8 cardinal compass points for the intervals described above for the observations in Mexico. In Mexico, young healthy melons had 20 to 40 SPW adults per leaf and cotton leaves had 2-3, 0.33, and 0.0 SPW adults per leaf at 1-10, 20, 50 meters. Mature squash that was failing, had 20 to 40 SPW adults per leaf and cotton leaves had 20, 3-4, and 0.29 SPW adults per leaf at 1-10, 20, and 50 meters. In partially disked squash, exposed leaves had 40 to 60 adult SPW per leaf, and cotton leaves had 30-40, 10, and 1-2 adult SPW. In contrast, cotton alone with no other SPW crop host plant nearby had no whiteflies at any of the intervals. Similarly, at the WCRL, in a mature but healthy crop of cantaloupe, the mean no. of SPW was 26.0 per leaf. The SPW adult count observations on cotton were divided into those upwind and downwind from the prevailing wind and means reported here are for 4 cardinal points per mean. SPW adults were 4.13 and 6.25, upwind and downwind, respectively for 10 meters; 2.5 and 3.5, upwind and downwind, respectively for 20 meters; and 0.08 and 0.39, upwind and downwind, respectively. These observations indicated that SPW adults dispersed lightly into cotton when melons or squash served as a healthy host to SPW adults but that dispersal was much heavier when the melons or squash crop weakened. The WCRL study also showed that wind does affect the dispersal outward from a central point.

INVESTIGATOR'S NAME (S): J.C. Allen[1], R.I. Carruthers[2], S.E. Naranjo[3], and T. Wagner[4]

AFFILIATION AND LOCATION: University of Florida, Gainesville[1], USDA-ARS, Phoenix, AZ[3], Starkville, MS[4], and Weslaco, TX[2]

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics and Dispersal

DATES COVERED BY REPORT: January-October 1992

Work has been initiated at four locations on the development of quantitative population models of the sweetpotato whitefly in relation to abiotic and biotic factors. Initial efforts have been directed into several areas of emphasis, including conceptual formulation of site-specific and regional population models, specification of data requirements for different aspects of these models, initiation of collaborative experimental efforts to meet some of the data requirements, the development of detailed process-oriented models, and the implementation of a GIS-like system to display and simulate sweetpotato whitefly movement and reproduction in a crop ecosystem.

The process-oriented models are being developed to integrate sweetpotato whitefly development, fecundity, natural enemy and pesticide induced mortality, and adult dispersal. Cultural and agronomic factors such as host plant resistance, irrigation scheduling, and defoliation timing are also being integrated into some of the models. The primary goals of models being developed at Phoenix and Starkville are to characterize detailed insect/plant interactions within the cotton ecosystem, while goals of efforts in Weslaco are to describe detailed interactions between sweetpotato whitefly, the abiotic environment and natural enemies across different cropping systems representative of the Rio Grande Valley.

Preliminary operational models are now available at two of the locations. In Florida, survey data has been used to parameterize simple models of crop growth and maturity, sweetpotato whitefly population growth, and movement between crops (see Section F). In Texas, an object-oriented model of sweetpotato whitefly population growth and interaction with a restricted number of natural enemies is operational. The model has not yet been verified and validated in relevant host crops with respect to population growth and phenology. Efforts in Starkville have primarily focused on developing temperature-dependent relationships to model developmental processes and work in Phoenix has focused on interrelationships between sweetpotato whitefly population growth, crop status and cultivar. Work is continuing to further improve, evaluate, and validate these models so that they can be used to help address basic questions associated with the management of this pest.

INVESTIGATOR'S NAME (S): George D. Butler, Jr., and T. J. Henneberry

AFFILIATION & LOCATION: Western Cotton Research Laboratory, USDA-ARS, Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics and Dispersal

DATES COVERED BY REPORT: September and October 1992

Bemisia tabaci has a very wide range of host plants. Cook in 1986 listed 506 plant names representing 74 families. With the recent appearance of the "B strain" a number of additional plants have undoubtedly been added to the host list. Thus with such a large worldwide list it may be more useful to identify those plants present in a particular locality that may be important hosts. From the crop production standpoint, some of these host plants may serve as significant overwintering sites for the whiteflies or as important sites for parasite development.

MODERATE INFESTATIONS

Antigonon leptopus
Brachyciton populneus
Caesalpinia mexicana
Camellia
Cercis canadensis
Grewia caffra
Hedera helix
Hydrangea occidentalis
Jasminum sambac
Larrea tridentata
Lonicera japonica
Myoporum parvifolium
Nandida domestica
Nerium
Passiflora pfordtii
Plumbago auriculata
Rosea banksiae 'Lutea'
Salix babylonica
Schinus trebenthifolius
Viburnum tinus
Vinca minor
Wisteria

SEVERE INFESTATIONS

Aniscanthus thurberi
Alyogyne huegelii
Bauhinia blakeana
Calendra
Cercidium floridum
Cercidium praecox
Chorisia insignis
Eremopbila maculata
Eumophila maculata
Ficus carica
Gardenia jasminoides
Hardenbergia comptoniana
Hibiscus
Koelreuteria paniculata
Lagerstroemia indica
Lantana camera
Mandevilla laxa
Morus alba
Persea (amer. x dryni.)
Podranea ricasoliana
Ruellia peninsularis
Vigna caracalla
Vinca major
Zaushineria california

INVESTIGATOR'S NAME (S): David N. Byrne, Jackie L. Blackmer, Robin J. Rathman and Athayde Tonhaska

AFFILIATION & LOCATION: University of Arizona, Tucson, AZ 85721

RESEARCH & IMPLEMENTATION AREA: Section A, Ecology, Population Dynamics and Dispersal

DATES COVERED BY REPORT: November 1, 1991 to October 31, 1992

The free-flight behavior of *Bemisia tabaci*, the sweet potato whitefly, was investigated in a vertical flight chamber. A mercury-vapor lamp presented from above induced a phototactic flight response that was dependent on time of day, sex, age and host quality. Although flight propensity was comparable from 0600 to 1900 h, flight duration was maximum between 0600 and 1000 h. Males flew longer than females and their mean flight duration remained constant throughout the day. Females flew longer from 0600 to 1200 h than from 1300 to 1900 h. Both sexes were capable of sustaining flight for more than 2 h, although less than 5% of those tested did so.

Flight activity also was influenced by age and by host quality. The propensity to take off, proportion exhibiting phototactic orientation and flight duration varied with the age of the whitefly. Host quality influenced the timing of flight behavior. Whiteflies reared on senescing tissue exhibited greater takeoff rates and longer phototactic flights up to 4 days following adult eclosion when compared to individuals reared on vegetative tissue. Thereafter, individuals reared on vegetative tissue exhibited greater response levels. Whitefly weight and adult survival also were influenced by host quality. Individuals reared on vegetative tissue weighed more and survived longer than did individuals reared on senescing tissue.

Whiteflies that responded to the overhead light initially exhibited a strong phototactic and photokinetic response. Over the course of the flight these responses declined and flight instability increased, as indicated by an overall decrease in the mean rate of climb, accompanied by an increase in the variability of this parameter and an increase in horizontal displacement. Although males and females displayed similar flight characteristics, females exhibited a greater rate of climb than did males, and for both sexes individuals that flew longer than 25 min had a greater rate of climb than did individuals that flew for less than 25 min.

In the laboratory we also found that sweet potato whiteflies can sustain flight at temperatures up to 47° C. Apparently temperature is not the limiting factor we thought it was. We also discovered that females are more phototactic and are probably the best colonizers. Finally, we believe that females do not exhibit the oogenesis-flight syndrome common in most insects, i.e., they do not postpone egg production until after migration. The more we learn about migration in whiteflies the closer we come to helping growers make informed decisions about production practices such as isolation and time of planting.

In the field we were conducting experiments to determine the effective migrational range of the sweet potato whitefly. A melon field was planted in a round configuration. Passive fan traps were placed along sixteen transects at distances from 15 to 1000 m. Every week from the end of August until mid-October the whiteflies in the field were marked with a fluorescent dust. During the two days following, marked whiteflies were collected from the traps to determine patterns and distance of migration. Some whiteflies were placed in alcohol so that we could later determine their egg load. Others were frozen so that we could later measure levels of lipids, protein and carbohydrate. Finally, some were placed in clip cages on plants to measure life history traits such as fecundity. All this is to determine in how far a whitefly can migrate and still colonize a new patch (crop).

INVESTIGATOR'S NAME (S): Raymond I. Carruthers

AFFILIATION & LOCATION: USDA-ARS, Biological Pest Control Research Unit, Weslaco, TX 78596

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: January - October 1992

Immature and adult SPW sampling has been initiated, and is being continued, to estimate age-specific population densities of the SPW in vegetable crops in the Rio Grande Valley of Texas. Based on preliminary sampling data (using whole leaf counts and leaf discs subsamples for immatures and whole plant counts for adults), detailed population data was collected during the 1991-92 winter/spring season in cole crops. SPW populations increased in cabbage plantings from less than 0.5 to 185 adults per plant from late December to early April. Although these population levels did not produce significant damage in the cabbage itself, infestations in cabbage allowed significant population increases in early spring (through ca. 3 SPW generations) which were followed by movement of SPW adults into spring planted melons where damage was more problematic. SPW and parasitism data from these sites and other factors such as abiotic conditions will be used to explain age-specific mortality estimates.

Initial SPW sampling problems on vegetable crops stimulated new research on the development of improved sampling technology for SPW immatures. One half day of field sample collection required two or more days of laboratory processing to produce accurate counts of SPW immatures on plant leaves, even when leaf disc subsampling was used. To improve our ability to sample adequate numbers of fields and subsamples within fields, we are now evaluating the use of "Still Video Imagery" (SVI) to electronically record field samples, a video laser disc to permanently store these samples, and an image analysis program to allow computer assisted assessment of immature SPW population counts. Although we are still in the developmental phase of this work, using Canon SVI cameras with macro lenses, we are able to record, store, and scan images of the leaf and identify SPW immatures using spectral and shape analysis. We are now working to improve resolution, recognition accuracy and to automate the counting process. Upon completion, we believe that field scouts will be able to record sample images directly in the field (50 images held/camera disc), return these discs to the laboratory and automatically count all nymphal stages by instar. Accuracy of these methods will be compared to counts made using laboratory technicians and an evaluation made as to speed and accuracy.

Population modeling of the SPW has been initiated using object oriented simulation which will be further developed and related to actual field situations within our field sampling program. In this effort we hope to tie site specific models to realistic spatial grids for regional analysis.

INVESTIGATOR'S NAME (S): Kent D. Elsey

AFFILIATION & LOCATION: USDA, ARS, SAA, Charleston, SC

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: 1992

Little is known of the potential for whitefly damage in the southeastern coastal plain, particularly in the spring when important vegetable crops, such as tomatoes, are grown. The capacity for whiteflies to overwinter and their cold tolerance is an important factor in potential for whiteflies to build up and damage crops in spring and early summer. In a 2 year study of *Bemisia tabaci* overwintering in coastal South Carolina it was found that whitefly density declined sharply on vegetables in fall and winter with slow recovery in spring. Low numbers were found during the winter on wild radish, a common weed host. In spring, whiteflies increased faster on potato and collard than other vegetables. Laboratory experiments showed that all whitefly stages were moderately cold tolerant, e.g. 50% of eggs can survive 80 hr at -2°C, however, most individuals of all stages were killed by 1 hr at -10°C. While few whiteflies survive even mild winters ($\bar{x}$ Jan. temp = 10.4 in 1991; 9.7 in 1992) on the coastal plain, nursery greenhouses were found to offer refuge for whiteflies during the winter. At the onset of warm weather, greenhouses were opened, thus allowing whiteflies to escape. In addition, care must be taken to insure that imported transplants are not infested prior to planting.

INVESTIGATOR'S NAME (S): R. A. Gonzalez, G. E. Goldman, E. T. Natwick, H. R. Rosenberg, J. I. Grieshop, S. R. Sutter, T. Funakoshi, S. Davila-Garcia.

AFFILIATION & LOCATION: County Director, Extension Specialist, Farm Advisor, Extension Specialist, Extension Specialist, Area Farm Advisor, Univ of CA Coop Extension, Research Manager, Research Analyst Calif Employment Development Department.

RESEARCH & IMPLEMENTATION AREA: Section A, Ecology, Population Dynamics and Dispersal

DATES COVERED BY REPORT: October 1991 - July 1992

The sweetpotato whitefly, *Bemisia tabaci* Biotype B (SPW) caused approximately $111 million in crop losses in Imperial Valley between October 1991 and February 1992. The project, utilizing crop damage estimates developed by the Imperial County Agricultural Commissioner's office, statistics regarding unemployment insurance benefits generated by the California Employment Development Department and economic multipliers developed by the U. S. Forest Service IMPLAN system, provides an analysis of the economic impact the SPW has had on the Imperial Valley.

Employment Development Department agricultural employment statistics reveal that the number of agricultural-related jobs dropped about 6,000 in January 1992 compared to January 1991. These same data show that the number of agricultural-related jobs continue to be lower through July 1992 than they were in 1991.

Decisions made by farmers not to grow crops that are extremely susceptible to whitefly infestation and damage will impact employment patterns in Imperial Valley. Because the sectors comprising today's economy are interdependent, changes in any one sector affect all other sectors. The totals of these changes are called multipliers. For example, a $1 million decline in melon production in Imperial Valley could produce corresponding estimate losses of $1,265,000 in local personal income and 42 jobs.

INVESTIGATOR'S NAME(S): K. M. Heinz and F. G. Zalom

AFFILIATION & LOCATION: Department of Entomology, Univ. of CA, Davis.

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: 1992

Laboratory and field assays of tomato cultivars and species have been completed as to their susceptibility to attack by *B. tabaci*. The results suggest that whitefly population growth varies significantly, dependent upon their tomato host plant. While a commercially available cultivar resistant to *B. tabaci* does not exist, resistance has been observed in the wild species *Lycopersicon pennellii*. Studies are currently being initiated to determine if this resistance is genetically based, and if the resistance trait may be incorporated into a breeding program to develop less susceptible tomato cultivars. A second component to these studies examines the influence of tomato plant characteristics on natural enemy efficacy. Preliminary results from this work suggest that cultivars with densely hirsute characters facilitate whitefly population growth and inhibit natural enemy search efficiency, and thus lead to a rapid buildup of *B. tabaci* populations.

INVESTIGATOR'S NAME(S): T. J. Henneberry, L. F-Jech, and H. Perkins

AFFILIATION & LOCATION: USDA-ARS, Phoenix, AZ & Clemson, SC

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: 1989-1991

A major problem of increasing concern to the cotton industry is the deposition of insect exudate called "honeydew," on cotton lint resulting in sticky cotton. The sticky cotton problem reduces ginning output and at the textile mill, interferes with machinery operation at several stages of lint processing. The results of 3 years research show a trend for increasing reducing sugars in relation to increasing sweetpotato whitefly (SPW), *Bemisia tabaci* Gennadius, populations and for 2 years with increasing dates of cotton lint harvest from 24 August to 17 November in 1989, and 2 August to 10 October in 1990. In 1991, reducing sugar content in harvested lint increased from 14 August to 17 October, but decreased on 4 and 19 November, following severe defoliation from leaf-feeding insects. Results in all years were highly variable and no statistically significant differences occurred. Results using the minicard method adopted by the textile industry as the reference method for cotton stickiness showed trends similar to those for reducing sugars increasing with SPW populations and dates of cotton harvest. However, results were also highly variable. Also, in our studies, with average reducing sugar content of cotton lint ranging from 0.2 to 0.5%, there were no consistent relationships to minicard ratings.

INVESTIGATOR'S NAME (S): R. E. Lynch and J. R. Chamberlin

AFFILIATION & LOCATION: USDA-ARS, Tifton, Georgia

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: September 1991 - September 1992

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius), attacking peanut, *Arachis hypogaea* L., in Georgia was identified as Strain B. Based on the Brooks-Dyar rule for geometric growth, four nymphal instars occurred on peanut. The average length and width (μm) for the instars were (mean $\pm$ SE): 1st = 207.8 $\pm$ 5.4, 120.9 $\pm$ 4.4; 2nd 314.9 $\pm$ 8.8, 194.0 $\pm$ 6.4; 3rd = 442.6 $\pm$ 11.2, 289.1 $\pm$ 8.0; and 4th = 619.3 $\pm$ 9.2, 428.7 $\pm$ 4.4. Few immatures were found on the terminal and second leaf of a lateral branch. They were most abundant on leaves 3, 4, and 5, and then numbers declined with an increase in leaf age. Immatures occurred on both the upper and lower leaf surfaces. Immatures were equally distributed among the tetrafoliates of a peanut leaf, but their location on the upper versus lower leaf surface varied over time. Yellow sticky traps placed in a horizontal position at ground or at canopy level and with the sticky surface upward were most effective in capture of adult sweetpotato whiteflies. The number of immatures on peanut leaves was only weakly related to the number of adults captured in sticky traps one week earlier.

INVESTIGATOR'S NAME (S): Steve E. Naranjo and Hollis M. Flint

AFFILIATION & LOCATION: USDA-ARS, Phoenix, AZ

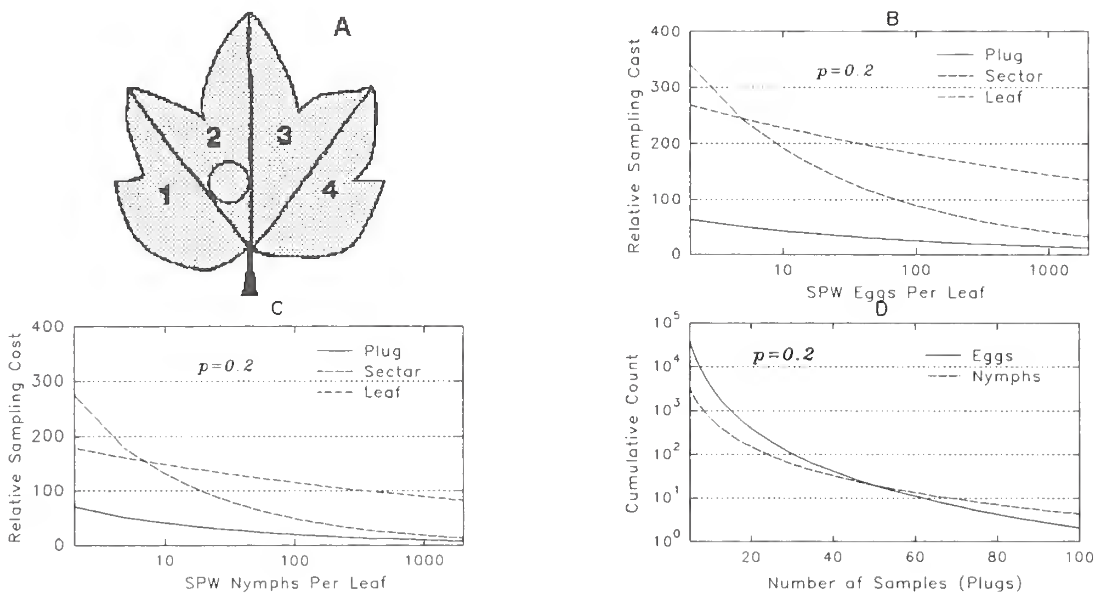
RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: June 1992 - Present

We are currently developing stage-specific SPW sampling plans in desert cotton. This summer we collected data sets from 29 field/date combinations of upland and long-staple cottons in Maricopa County from mid-June to late-August. For eggs and nymphs (crawlers-pupae) we examined distributions within fields, within plants and within leaves, and estimated variance components to determine the most efficient sample unit. Counting down from the terminal (node=1) on the mainstem, the most infested leaves were at nodes 3-5 and 5-7 for eggs and nymphs, respectively. These same nodes consistently had the lowest coefficients of variation (CV). Analysis of within leaf distributions indicated that a $3.88cm^2$ plug taken at the base of leaf sector 2 (see A below) was highly correlated ($r>0.84$) with whole leaf counts of both eggs and nymphs and in comparison with sector and whole leaf counts was the most efficient sample unit (see B and C below). Using a plug from sector 2 taken from a mainstem leaf at node 5, preliminary plans were formulated using Green's fixed-precision, sequential sampling algorithm (see D below).

Leaf turn counts (0600 H) for adult SPW were higher, but less variable using leaves near the top of the plant in comparison with mid- or lower-canopy leaves. Top leaf counts were highly correlated with whole plant adult counts ($r=0.91$) and with egg ($r=0.91$) and nymphal ($r=0.87$) counts. Sticky yellow cylinders (9.7 cm dia.) were consistently less variable than yellow cards (15.2 x 15.2 cm, both sides) placed within plots at canopy height and both traps were highly correlated with egg and nymphal counts ($r>0.89$).

Presences-absence plans are being evaluated as a substitute for complete enumeration for decision-making application.



INVESTIGATOR'S NAME (S): John C. Palumbo

AFFILIATION & LOCATION: University of Arizona, Dept. Of Entomology

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: January 1992 - December 1992

Studies were conducted in the spring of 1992 to investigate several sampling methods for estimating adult abundance of sweetpotato whitefly (SPW) on spring cantaloupes. Three sampling methods were examined: yellow sticky traps (ST), direct visual observations of adults on the undersides of leaves (LT), and a modified Vacuum "Hand-Vac" procedure (HV). Comparisons were made in commercial melon fields, untreated experimental plots, and small plot efficacy trials.

Generally, similar trends in adult abundance were observed with each sample method at each site. Preliminary comparison among sampling procedures indicated that efficiency in adult estimates varied by experimental site. In commercial fields, the relative variation (RV) values for the LT, HV and ST methods were less than 25 on most sampling occasions. RV values were generally lowest with ST where this value was less than 10 on many occasions. In addition, estimates of adults/sample derived from all three methods were significantly correlated with egg densities on young terminal leaves and nymph densities on crown leaves.

In the untreated experimental plots, all sample methods were less efficient due to greater variation associated with mean estimates. The HV and LT methods generally yielded means with a lower RV value than the ST, but ranged from a value of 12 to 48 depending on SPW density and plant size. The HV and LT methods were highly correlated with immature counts on each sample occasion. Correlations between adults estimated with ST and immature counts were not consistently observed.

The efficiency of adult sample methods was extremely variable when compared in efficacy trials. The mean number of adults/sample and associated variation derived with each sample method differed with type of insecticide applied and time of sample. RV values were generally lower for ST when compared in plots treated with a pyrethroid insecticide (bifenthrin) or untreated plots, whereas LT and HV estimates were less variable when compared in plots treated with a insect growth regulator (buprofusin). In addition, variation of adult estimates differed depending whether samples were taken prior to or after an application. Mean adult numbers with LT and HV were closely correlated with egg and immature densities on each sample occasion. Estimates with ST showed that adults and immatures were not correlated. Adult abundance differed for sample methods depending on time of day and selection of sample unit. More adults per leaf were generally observed on plants using the LT method at 0600 hrs as compared to 1300 hrs. This relationship was not as evident when populations densities were high. A significantly greater number of adults per leaf were estimated with LT on leaves located near the terminal of the vine as opposed to leaves in the crown area near the base of the plant. This trend was observed regardless of population density. In general, more adults were collected with the HV procedure in the morning (0600 hr) as opposed to the afternoon (1300 hr). Similarly, a greater number of adults were captured on ST during the morning (0600-1000) than at any other time of day.

INVESTIGATOR'S NAME (S) : Thomas M. Perring and Tom S. Bellows

AFFILIATION & LOCATION: Dept. Entomology, Univ. Calif., Riverside

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: 1 April 1992 - present

We have documented the contribution of major crop and weed plants grown in the Imperial Valley of California to the seasonal abundance of whiteflies and their natural enemies. We sampled using yellow sticky cards for adult estimates, timed nymphal counts on plants in the field, and intensive microscope examination of nymphs to determine nymphal survival and parasitism ratios. For the nymphal survey, we sampled over 300 site/plant locations every 2 weeks.

Cucurbits (primarily cantaloupe) provide the earliest, most suitable host of any plant grown in the area. Whiteflies densities increased in this crop through April and May and by the May-July harvest period, large numbers of whiteflies migrated throughout the Valley. Following cantaloupe, both in seasonality and whitefly abundance was cotton. Whiteflies infested cotton and nymphal density increased on this crop through September, at which time cotton was defoliated. this time, alfalfa fields became inundated with migrating whiteflies and it was not until this time that nymphs began showing up in our alfalfa samples. These data suggest that alfalfa will support whitefly growth and reproduction, but only after large numbers are present in the area.

Of the 34 weed species sampled, sowthistle, *Sonchus oleraceus* L. and velvetleaf, *Albutilon theophrasti* Medic. were the best whitefly hosts through the early season (April-July). Numbers declined on sowthistle after this time when this plant became less abundant in the Valley. However, whiteflies continued to increase on velvetleaf through October. In September, sunflower *Helianthus annuus* L. and Wright groundcherry, *Physalis acutifoli* (Miers) Sandwith became major whitefly producers. The common weeds, alkali sida, *Sida hederacea* (Dougl.) Torr., cheeseweed, *Malva parviflora* L., lambsquarter, *Chenopodium album* L., and prickly lettuce, *Lactuca serriola* L., had little or no whitefly development, although whitefly adults were observed resting on these plants.

Of the crop plants sampled, parasite activity (*Eretmocerus* sp. and *Encarsi* sp.) was most prevalent in cotton. On this host, parasitism rates averaged as high as 30%. Little parasitism was present in cucurbits or alfalfa. Of the weeds sampled, parasitism was low on most plants. However parasitism rates on telegraph weed, *Heterotheca grandiflora* Nutt. and sunflower reached 81% and 30%, respectively.

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RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: June 1991 - October 1992

Area-wide sampling studies were initiated in 1991 and continued in 1992 to provide information for improved sweetpotato whitefly (SPW) management in the Lower Rio Grande Valley of Texas. The objectives were: (1) to monitor migration of SPW adults along three transects across two counties using yellow sticky traps, (2) to monitor populations of SPW within selected commercial vegetable and cotton fields with yellow sticky traps for comparison to transect data, (3) to compare sampling methods for SPW in cantaloupe.

<u>Sampling Migrating Whitefly Adults (1991)</u> The increase and decline of migrating adults was associated with the increase and decline of the cotton crop within the sample area. Correlation analysis of trap counts to acreage within a given distance of the traps indicated that, overall, SPW numbers were positively correlated with acreage near the end of the season. However, on June 10 along transect #2 between McAllen and Harlingen a negative correlation indicated that the highest SPW numbers were associated with the smaller cotton acreage. The smaller fields in this area were those fields that closely followed spring vegetables. Also, within the most heavily infested area along transect #2 in the middle sector, earlier positive correlations between acreage and SPW counts were observed. This could suggest that the infestation began earlier in this area than other areas in 1991.

In 1992 measurements of migration of SPW adults in the area sampled suggest that the infestation increases dramatically in the spring, continues into the cotton crop, where peak migrations occur near the time of cotton defoliation, and declines later in the fall. Three periods of heavier migration relative to samples taken before and after that date were February 23, May 19 and July 28 - August 11. These periods of more intense SPW movement appeared to be associated with cabbage harvest, melon harvest, and cotton defoliation, respectively.

<u>Sampling Within Fields</u> Whitefly numbers in individual fields were generally higher that numbers on road traps from surrounding areas, and during periods of heavy migration all susceptible fields within the affected area experience high infestation pressure. Samples from individual vegetable fields indicate that whitefly populations increased at the end of the season despite commercial efforts to control SPW and that residue left abandoned were continuous sources of SPW adults after the season was completed. The subsequent build up of SPW in cotton after the spring vegetable season was greater in areas which experienced higher SPW numbers in the spring. The association of heavier SPW infestations in cotton fields near spring vegetable fields suggest that a carry over of SPW from spring vegetables may be increasing the SPW problem in cotton. The overall numbers of SPW were less in 1992 compared to 1991 and it is believed that timely controls based on whitefly reports and cultural practices played a large role in reducing the SPW population.

<u>Sampling Comparison Studies</u> Of the samples compared, the better correlation with total numbers of immatures were large nymphs > eggs > adults on leaves, respectively. This suggests that large nymphs are the best stage to sample for estimating the total number of immature SPW present on the crop. Also correlations with adults on leaves were similar for all immature stages. The regressions for large nymphs and eggs on total immatures provided a better fit than other stages. Numbers of large nymphs were significantly related to adult numbers as well, but the relationship was not very precise. The SPW adult count per trap was significantly related to SPW adults and immatures on the crop, but traps did not provide a good indicator of adults per leaf and the relationship with total immature stages was weak.

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RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: 1989-1992

Weekly leaf samples of all life stages of *B. tabaci* (B Strain) on greenhouse poinsettias under sprayed and unsprayed (biological control) conditions have been collected for the duration of the Christmas crop. Within- and between-plant dispersion patterns have shown an expected high degree of aggregation. Within-plant dispersion patterns under sprayed and unsprayed conditions can differ. Utilizing mean-variance relationships, fixed-precision sampling plans for whitefly nymphs are under development. Optimal numbers of leaves per plant and plants per unit growing area are being evaluated. Statewide surveys of whitefly levels on the crop at time of sale for the past three years may lead to the development of action thresholds and sequential sampling plans.

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AFFILIATION & LOCATION: University of Florida, Gulf Coast Research & Education Center, Bradenton, Florida

RESEARCH & IMPLEMENTATION AREA: Section A: Ecology, Population Dynamics, and Dispersal

DATES COVERED BY REPORT: January 1991 - August 1992

In order to identify possible reservoirs of the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), for tomatoes in west-central Florida, adult populations were sampled in commercial vegetable fields and weeds during 1991-92 using yellow sticky traps. Single 1-5/8 inch square traps were placed in the interiors of fields of each commodity and on the weedy perimeters of tomato fields and were replaced weekly. Whitefly populations in cabbage and potato fields, which were planted in the fall and harvested in the spring, were high from November to April when populations on tomato were low. Therefore, these crops could serve as reservoirs of the whitefly for spring tomato crops transplanted in January and February. The numbers of adults trapped in cucumber and squash generally peaked prior to those trapped in tomato. Since, these crops generally are planted at or near the same time as tomato in the fall but are shorter season crops than tomato, they can serve as mid-season reservoirs of the whitefly for fall-planted tomatoes. The numbers of adults trapped in weeds tended to parallel those trapped in tomato fields and declined to very low numbers during the summer off-season. This suggested that weeds were more affected by production fields than vice versa. Mortality of sweetpotato whitefly nymphs on weeds due to parasitization and apparent predation ranged from 40 to 90% in the fall of 1991 and from 10 to 70% in 1992. This supports the observation that weeds probably serve as sources of relatively low numbers of sweetpotato whitefly adults and serve as reservoirs of natural enemies. Therefore, in order to conserve natural enemies, routine scouting within pest management programs should include periodic sampling of weeds on the perimeters of tomato fields to determine the extent of sweetpotato whitefly populations and natural mortality before making decisions regarding management of these weeds.

TABLE A. Summary of Research Progress for Section A, Ecology, Population Dynamics, and Dispersal, in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	Progress Achieved No	Significance
A.1 Define biology, phenology, and demography of SPW on greenhouse, field crop and wild host plants.	Systematic study of SPW on cultivated and weed hosts, seasonal time of occurrenee, habitat.	X		Extensive host range of SPW, including weeds, landscape vegetation and cultivated crops affords large biomass for population development. Importance of particular host plants is location dependent. Parasitism is extensive in some ecosystems, providing a base for augmentation and conservation. Population cycling and movement between sequentially planted crop hosts and naturally occurring weed hosts is evident. Low winter temperatures are detrimental to survival and population development in northern latitudes.
A.2 Develop efficient SPW sampling plans for research and decision making purposes.	Determine spatial distributions, define sample units for immature and adult SPW, examine variance components, optimize sample number and allocation.	X		Development of adult and immature SPW sampling methods progressed favorably. Correlations between adult and immature counts ranged from good to poor depending on adult sampling methods and the host crops examined. Vertical population distributions within host plants suggests sampling in the top 20% of the plant may provide good population estimates. Leaf disc subsamples from the 5th main stem node on cotton was the most efficient sample unit for eggs and nymphs. Efficient and precise sampling plans are being developed as critical components of SPW management programs in greenhouse and field crops.
A.3 Develop economic thresholds for SPW in relation to feeding damage, honeydew production and virus transmission.	Determine components of yield and quality affected by SPW feeding, virus transmission and honey-dew production on crop studied.	X		Limited progress was achieved on the overall goal. Research in cotton showed that reducing sugars in cotton lint increased during the season but did not reach 1%. No relationship was shown between sugar content and standard minicard fiber tests. There is a critical need for rapid field lint tests that relate to textile mill stickiness. Studies in melons established SPW age-specific relationships to melon harvest weights, % sugars, and other crop performance characteristics. Preliminary action thresholds were reported.
A.4 Develop and test population models to describe and predict SPW dynamics.	Determine model goals, define preliminary model structures and identify data needs, evaluate existing biological information.	X		Model goals and structures have been formalized and data needs identified. Life process oriented models and more general spatial models are being developed to integrate the influences of abiotic and biotic factors on site-specific and regional population dynamics. Models will serve a valuable role in helping identify research needs, assessing priorities, and aiding the development of management systems.
A.5 Determine factors influencing SPW dispersal.	Determine relationships between crop phenology, crop status and SPW dispersal.	X		Some biological and ecological factors affecting SPW dispersal have been identified. Flight can be sustained at temperatures up to 47°C and can be sustained up to 2 h in a small fraction of the population. Diet, sex and age affect flight performance. Understanding the factors that affect dispersal within and between crop systems can provide a base for development of management strategies.

TABLE A - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	Progress Achieved No	Significance
A.6 Determine impact of dispersal on population dynamics in green-house, field crop, and weed host systems.	Develop marking methods (immunological, rubidium, genetical), determine population development and phenology on various crops.	X		Adult mark and recapture studies provided quantitative estimates of dispersal from melons and observational studies showed declining densities of SPW in cotton at progressively greater distances from source melons. Adult trapping studies in Texas indicated overall increases and declines in capture were correlated with increase and decline of the cotton crop. These approaches can ultimately establish the role of dispersal in local and regional SPW population development.

RESEARCH SUMMARY

Section A: Ecology, Population Dynamics and Dispersal

Compiled by
S. Naranjo & H. Browning

A.1. Define biology, phenology, and demography of SPW on greenhouse, field crop and wild host plants

Considerable effort was devoted to identifying important hosts of SPW and determining the seasonal sequence of occurrence in locations from California to Florida.
Extensive adult and nymphal surveys in the Imperial Valley, California indicated a cultivated host sequence pattern of cucurbits to cotton to alfalfa from the spring to late-fall. The major weed hosts over the season included velvetleaf in the spring, and sunflower and groundcherry beginning in the early fall, with sowthistle being most important in the spring, but providing sites for reproduction through October. Parasite activity was greatest on cotton, telegragh weed and sunflower. Fall surveys of landscape plants in the Phoenix area indicated moderate infestations on 22 species and severe infestations on 24 species, including many abundant hosts such as Palo Verde trees, *Hibiscus*, *Lantana*, and *Vinca*. These hosts may serve as significant overwintering sites for sweetpotato whitefly and their parasitoids.

In the Rio Grande Valley of Texas populations of sweetpotato whitefly increased on cabbage from December through April. These populations spawned significant infestations in spring melons. Work is currently underway to measure the impact of biotic and abiotic factors on age-specific mortality of sweetpotato whitefly. Populations of the sweetpotato whitefly in the Rio Grande Valley were comparatively lower in 1992 than in 1991. Populations were high in vegetables at the end of the growing season and vegetable crop residues in the late spring provided continuity for sweetpotato whitefly to later infest cotton. Higher populations in cotton were associated with high populations in nearby spring vegetable fields. In coastal South Carolina sweetpotato whitefly populations declined rapidly on vegetables in the fall with slow recovery in the spring. Wild radish and greenhouses provided overwintering sites and spring populations increased comparatively faster on potato and collards. Typical winter temperatures appear detrimental to sweetpotato whitefly survival in this area.

Seasonal patterns of sweetpotato whitefly abundance in west-central Florida differed somewhat from other parts of the country. Adult surveys indicated that winter/spring cabbage and potato crops may provide a reservoir for subsequent invasion of spring tomatoes. Adult populations peaked earlier in fall planted cucumber and squash than tomato and may act as a mid-season source of sweetpotato whitefly for fall tomatoes. Adult populations in weeds paralleled those in tomato during the growing season, but declined to low numbers during the summer off-season. Weeds appear to contribute few sweetpotato whiteflies to nearby crops, but may be an important source of parasitoids.

Some work was conducted to examine the influence of different host cultivars on sweetpotato whitefly. Population growth varied depending on tomato cultivar. Studies are being initiated to examine the potential of incorporating wild *Lycopersicon* characters into cultivated tomato to enhance resistance. Hirsute cultivars facilitate sweetpotato whitefly population development, but appear to inhibit natural enemy efficacy.

A.2. Develop efficient SPW sampling plans for research and decision making purposes

Sampling plans for adult and immature SPW are currently under development for greenhouse, vegetable, and field crops. Three adult sampling methods were evaluated for use in spring cantaloupes in Arizona. In

general, yellow sticky traps, hand-vac samples and leaf-turn counts were equally variable in commercial fields, but less variable for hand-vac and leaf-turn samples in smaller experimental plots. All methods were correlated with egg and nymphal leaf counts in commercial sites, but only hand-vac and leaf-turns were consistently correlated in experimental plots. In insecticidal trials, the variability of adult sampling and correlations with immature counts varied with the material used. All methods recorded higher counts during morning hours (0600-1000 h) and adult were more abundant on leaves near the terminal than on leaves near the plant base. Sampling on cantaloupes in Texas indicated that total immature counts were best correlated with large nymphal counts and less well correlated with egg and adult leaf counts. Adult leaf counts were equally correlated with all immature stages. Sticky trap counts generally did not provide good estimates of adult leaf counts or counts of total immatures. In cotton within-field cylindrical sticky traps were found to be less variable than flat cards of equal area, and both sticky trap counts were highly correlated with adult leaf-turn counts and both egg and nymphal counts. In Georgia sticky traps placed horizontally at ground or canopy level in peanuts captured the most adults but trap counts were poorly correlated with immature counts taken one week later.

Extensive sampling data have been collected for greenhouse poinsettias in New York under sprayed and unsprayed conditions. Within- and between-plant dispersions are being examined to determine optimal sample units and fixed-precision sampling plans are under development. Sampling plans for egg, nymphal and adult SPW are being developed for cotton in Arizona. Within-leaf, within-plant, and between-plant distributions were examined from July through September. A single 3.88 cm^2 plug, taken from the basal portion of a 5th mainstem node leaf (counting down from the terminal), was determined to be the most efficient sample unit for eggs and nymphs. Preliminary fixed-precision sequential sampling plans have been formulated. Immature distributions were examined on peanuts in Georgia. Counting down from the terminal, sweetpotato whitefly were most abundant on leaves 3 through 5. Immature were found on both upper and lower leaf surfaces and were uniformly distributed among peanut leaflets.

The use of "Still Video Imagery" is being explored for sampling of sweetpotato whitefly immatures on vegetable crops in Texas. The system electronically records leaf images and uses spectral and shape analysis to enumerate the various nymphal stages. Progress is being made to increase image resolution and recognition accuracy, and to automate the counting process. Methods will be compared to manual counts.

A.3. Develop economic thresholds for SPW in relation to feeding damage, honeydew production and virus transmission

Some progress has been made in understanding the relationship between sweetpotato whitefly abundance and crop damage. Studies in central Arizona showed a trend for increasing amounts of reducing sugars with increasing SPW populations in cotton and with progressively later dates of lint harvest. Minicard ratings, an industry standard for lint stickiness, showed similar trends, but the relationship between reducing sugars and minicard ratings was poor. Work in the lower Rio Grande Valley (see Section F) showed that increases in the number of immature sweetpotato whitefly was associated with declines in cantaloupe weight, the number of boxes and sugar content, and increases in the number of fruits per box and molds and mildews. Overall, large nymphal counts were shown to be the best indicators of many of the yield and damage components. Based on 10% reductions in yield components a preliminary action threshold of 1 large nymph per in^2 (6th nodal leaf) or 3 adults (3rd nodal leaf) was determined.

It was estimated that sweetpotato whitefly caused around $111 million in losses in Imperial Valley, California from October 1991 to February 1992. This estimate was based on crop damage estimates and unemployment statistics, and incorporated economic multipliers which reflected the cascading effects of whitefly infestation to the local economy.

A.4. Develop and test population models to describe and predict SPW dynamics

Research is underway at four locations to develop models to study and predict sweetpotato whitefly population dynamics in particular crops and within regional cropping systems. Model goals and structures have been formalized and collaborative research efforts have been formed to provide the necessary data. In Texas, an object-oriented programming approach is being used to model sweetpotato whitefly population growth and natural enemy interactions in various crops in the Rio Grande Valley. The goal is to link site-specific models to simulate spatial dynamics on a regional grid. In Florida a grid-based simulation of sweetpotato whitefly reproduction and movement is being developed to examine the temporal and spatial dynamics of pest infestation over a multi-crop area. Survey data collected over wide spatial areas are being used to parameterize simple algorithms for crop growth, and insect growth and dispersal. A primary goal of this effort is to investigate crop spatial and temporal patterns in relation to SPW vulnerability and subsequent invasion. Efforts in Arizona and Mississippi are focusing on developing process-level models of sweetpotato whitefly population dynamics in the cotton ecosystem. A primary goal is to incorporate cultural and agronomic factors such as host plant resistance, irrigation management, and the timing of crop termination to explore and aid the development of more effective crop management systems. The evaluation and validation of some models is underway.

A.5. Determine factors influencing SPW dispersal.

Considerable progress has been made in defining some of the biological and ecological factors influencing SPW flight activity. A vertical flight chamber was used to study the influence of factors such as sex, age, host quality and time of day on sweetpotato whitefly flight behavior. A small percentage (<5%) of individuals from both sexes were able to sustain flight for more than 2 h, but females were more inclined to display long flights between 0600-1000 h while males initiated long flights during all daylight hours. Females were more phototactic and photokinetic and displayed faster rates of climb than males. In comparison to individuals reared on vegetative tissue, whiteflies reared on senescing tissue showed greater flight activity up to 4 d following eclosion. Flight activity also varied with adult age and was sustained at temperatures up to 47°C. Evidence suggested that females do not exhibit the typical oogenesis-flight syndrome.

A.6. Determine impact of dispersal on population dynamics in greenhouse, field crop, and weed host systems.

Some progress has been made in directly measuring rates of sweetpotato whitefly movement, and trapping studies have provided information on movement relative to season and crop sequences. Mark-recapture studies in Arizona estimated patterns and distances of migrations by sweetpotato whiteflies from melon fields during August through October. Subsamples of dispersing whiteflies were collected to determine characteristics such as egg loads, lipid, carbohydrate and protein content, and levels of female fecundity.

Studies in Sonora, Mexico and Arizona indicated that fewer sweetpotato whiteflies were found in cotton at progressively greater distances from adjacent source plots of cantaloupes or squash. The numbers of whiteflies increased in cotton as cucurbit host quality declined, however, the pattern of distribution within cotton remained approximately the same. Adult trapping studies along sampling transects in Texas indicated that the overall increase and decline in capture of adult sweetpotato whitefly was correlated with the increase and decline of the cotton crop within the area. The periods of heaviest trap catches were late-February, mid-May, and mid-summer, corresponding with cabbage harvest, melon harvest, and cotton defoliation, respectively. The same type of pattern was observed in the Imperial Valley of California where whitefly migration events followed cucurbit harvest from May-July and cotton defoliation in late-summer when large number of SPW were found in alfalfa.

B. Fundamental Research, Behavior, Biochemistry, Biotypes,Morphology, Physiology, Systematics, Virus Diseases and Vector Interactions

Chairs: Richard T. Mayer and Judith K. Brown

Committee Members: K. Hoelmer, J. Duffus, M. Houck, D. Hendrix, and D. Jimenez

1. Abstracts
2. Table B
3. Research Summary

INVESTIGATOR'S NAME (S) : J. K. Brown, D. C. Fletcher, N. P. Goldberg, and S. A. Coats

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RESEARCH & IMPLEMENTATION AREA : Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT : January, 1992 - December, 1992

Biogeographic surveys of *Bemisia tabaci* Genn. populations from 1989 to the present indicate that the new 'B' biotype is present in nearly every major agricultural locale in the Southwestern and Southeastern US and Hawaii, Northern Mexico, the Caribbean Basin, the Eastern Caribbean, Central America, and in at least several countries in South America. Biotypes were monitored using native polyacrylamide gel electrophoresis of established esterase markers. The 'A' or indigenous Southwestern US population and the prototype 'B' population maintained in the Tucson laboratory were used as standards. In a survey of other worldwide populations, characteristic 'A' and 'B' type esterase patterns were identified, and at least eighteen additional distinct esterase patterns were observed. Biological characteristics have not presently been ascertained for the majority of the esterase-typed populations.

Attempts to successfully produce genetic crosses between the 'A' and 'B' biotypes have resulted in the production of none to few female progeny from either 'A' X 'B' or 'B' X 'A' matings. In all cases, male and female progeny had the esterase type characteristic of the female parent.

Studies involving biological and molecular characterization of several newly encountered whitefly-transmitted geminiviruses affecting tomato, pepper, cotton, and cucurbit plantings in the region are underway. Hybridization profiles and partial host ranges have been generated for over twelve new viruses of tomato and pepper in the US. PCR-based diagnostic methods are being developed in order to catalog the geminiviruses in the region, and to ascertain the prevalence and distribution of these new viral pathogens in cropping systems in the US and adjacent geographically proximal locales. Molecular cloning and sequencing of several geminiviruses affecting tomato, pepper, and cotton are underway. Clones will be used as virus-specific probes, and as sources of specific viral genes for the development of resistant varieties using genetic engineering and classical breeding strategies.

INVESTIGATOR'S NAMES: James S. Buckner, Dennis R. Nelson and John G. Riemann

AFFILIATION & LOCATION: Biosciences Research Laboratory, ARS-USDA, Fargo, ND, 58105

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: March to November, 1992.

Comparative studies have been conducted on *Bemisia tabaci* and on *Trialeurodes vaporariorum.* The structures of the wax glands have been determined using transmission and scanning electron microscopy.

Most ultrastructural observations were made on *T. vaporariorum.* However, observations on *B. tabaci* showed that the wax glands of the two species are similar. In each gland, wax appeared to be secreted into common pools beneath the cuticle prior to moving to the exterior through cuticular pores. Secretion was at a high level in recently eclosed individuals, while in week-old individuals the glands appeared less active and were degenerate in some individuals.

No nerves were found in the glands. Especially in older individuals, the cytoplasm of the glands contained many small dense particles thought to be aggregates of metabolic waste material. Cytological studies were initiated on other cuticular glands, including the nymphal wax glands and the dorsal discoidal pores.

The surface lipids have been characterized in newly emerged insects and adult insects, and the wax particles have been characterized in adult insects.

The surface lipids of both species have very small amounts of hydrocarbons and large amounts of free alcohols, aldehydes, and wax esters. Triglycerides and free fatty acids are also present and are currently being characterized.

T. vaporariorum adults are characterized by large amounts of 32-carbon alcohols and aldehydes while *B. tabaci* are characterized by large amounts of 34-carbon alcohols and aldehydes.

The two species are further differentiated by the wax esters present in the surface lipids: *T. vaporariorum* adults have a 42-carbon wax ester as the major ester component while *B. tabaci* adults have a 46-carbon wax ester as the major ester component. In both species, the major fatty acid component of the major wax ester is 20-carbons in length.

INVESTIGATOR'S NAME (S): Bruce C. Campbell

AFFILIATION & LOCATION: USDA-ARS, Albany, CA

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY RESEARCH: December 1991 to December 1992

Clark MA, Baumann, L, Munson, MA, Baumann, P, Campbell BC, Duffus JE, Osborne LS, Moran NA. The enbacterial endosymbionts of whiteflies (Homoptera: Aleyrodoidea) constitute a lineage distinct from the endosymbionts of aphids and mealybugs. Current Microbiology 25: 119-123 (1992)

Whiteflies contain enbacterial endosymbionts localized within host cells known as mycetocytes. Sequence analysis of the genes for the 16S RRNA of the endosymbionts of *Bemisia tabaci*, *Siphoninus phillyreae*, and *Trialeurodes vaporariorum* indicates that these organisms are closely related and constitute a distinct lineage within the gamma subdivision of the *Proteobacteria.* The endosymbionts of whiteflies are unrelated to the endosymbionts of aphids and mealybugs, which are in two separate lineages.

Campbell BC. Congruent evolution between whiteflies (Homoptera: Aleyrodidae) and their bacterial endosymbionts based on respective 18S and 16S rDNAs. Current Microbiology: 26: 129-132 (1993).

Whiteflies possess heritable eubacterial endosymbionts sustained in specialized organ-like structures called mycetomes. Comparison of distances between the ash whitefly, *S. phillyreae*, and two biotypes ("A" and "B") of the sweetpotato whitefly, *B. tabaci*, based on sequence analysis of genes for 18S rRNAs (rDNAs) were equivalent to the distances represented by the 16S rDNAs of their respective endosymbionts. This finding indicates that evolutionary divergence in whitefly-hosts and their endosymbionts is congruent. The nucleotide sequences of the 18S rDNAs and endosymbiont 16S rDNAs indicate the two biotypes of *B. tabaci* are conspecific.

Campbell BC, Steffen-Campbell JD, Gill RJ. Phylogeny of members of the Aleyrodoidea based on molecular phylogenetic analysis of components of the RRNA transcript. Molecular Phylogenetics & Evolution.

Portions of the multigene family of the rRNA transcipt of representatives of the superfamily Aleyrodoidea have been sequenced in order to elucidate their phylogenetic affiliations. The number of nucleotides compared are equivalent to over 3,000 character-states. Tree topologies based on 18S rDNA and the D2 expansion segment of the 28S rDNA (28S D2ex) are identical even though the 28S D2ex shows an evolutionary rate 2-3 times that of the 18S rDNA. Genetic distances show that whiteflies diverged more than 50 million years before the aphids. Results show that *B. tabaci, S. phillyreae and Aleurodes spiraeiodes* are descended from an immediate common ancestor with *T. vaporariorum* placed in a paraphyletic clade.

INVESTIGATOR'S NAME (S): S. A. Coats[1], D. L. Hendrix[2], and J. K. Brown.[1]

AFFILIATION & LOCATION: Department of Plant Sciences, University of Arizona, Tucson, AZ 85721[1]; USDA-ARS, Western Cotton Research Laboratory, 4135 E. Broadway, Phoenix, AZ 85040[2].

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: January 15, 1992 - December 31, 1992

In previous studies, non-specific esterase banding patterns have been used to differentiate between the 'A' and 'B' populations of *Bemisia tabaci* Genn. These populations are now known to be biologically and genetically different, but are morphologically indistinguishable. Current studies are under way to determine the biochemical basis for the observed differences between the two populations with respect to differential esterase banding patterns and associated acetylcholinesterase (ACHE) activity.

High resolution analyses of non-specific esterase profiles were undertaken to delineate biochemical differences that are unique to the 'A' and 'B' populations. The identity of the predominant components of the non-specific esterase profiles was investigated using: 1) isoelectricfocusing, 2) two- dimensional, native, pore-limiting, and gradient polyacrylamide gel electrophoresis, and 3) Ferguson Plot analysis. Characteristics of the (putative) AChE's were further investigated in microtiter assays using an AChE-specific inhibitor.

The results of these studies indicate that there are differences in size isomeric relationships and enzymatic activities of the AChE's in the 'A' and 'B' populations. The AChE's were shown to be charge isomers with different molecular weights. In microtiter assays, the ACHE in the 'A' population was inhibited by propoxur to a greater extent than in the 'B' population. Thus, the 'B' population appears to have a mutant form of ACHE. These data also suggest that the 'A' and 'B' populations differ in the ability to detoxify specific classes of insecticides and other chemical compounds.

INVESTIGATOR'S NAME (S): A. C. Cohen, T. J. Henneberry, D. Hendrix, and R. Staten.

AFFILIATION & LOCATION: Western Cotton Research Laboratory, USDA-ARS, Phoenix, AZ.

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: October 1, 1991 - October 1, 1992

Rates of water loss and oxygen consumption and thermal tolerances were measured for SPW of strains A and B. Rates of water loss for nymphs of both strains were not significantly different, but for each strain, rates of loss were as much as 10% of their body weight/hour. Rates of loss were less in adults than in nymphs, reaching only about 2-3% of the total body weight/ hour. Resting metabolic rates were similar to those measured for similar sized parasitic insects. Temperature tolerance for SPW as measured by critical thermal maximum (CTM) was about 52°C, significantly greater than that of several species of parasites and predators.

Detailed biochemical observations have demonstrated an amylase in SPW's indicating a feeding target other than phloem. Details of the kinetics, specificity, isoelectric point, pH optima, weight specific activity and stage specific activity have been determined. Feeding studies of nymphs of SPW "B" strain have been made with histological sectioning and light microscopy. More than 30% of the nymphs examined had stylets placed in plant tissues other than phloem. Evidences of severe plant damage were found, especially destruction of chloroplasts and starch granules. This information suggests that SPW use other plant tissues than phloem for some of their feeding. A completely defined artificial diet has been studied for use as an SPW media. It supports adults for 2 weeks and 1st instar nymphs for 4-7 days. It allows the 1st instars to grow to pre-ecdysis, but only a small number (< 1%) have become second instars. Rates of honeydew excretion have been measured both on artificial diets and on host plants, and those rates from plant-feeding are far greater than those on artificial diet.

INVESTIGATOR'S NAME (S): Rebecca Creamer

AFFILIATION & LOCATION: Dept. of Plant Pathology, University of California; Riverside, CA

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: Jan 1992-Jan 1993

There are several SPW projects ongoing in the laboratory. One project has been to develop a non-radioactive dot blot hybridization system for use in detecting geminivirus in laboratories with fairly simple facilities. The system works well to detect certain geminiviruses in specific plants. We are currently optimizing the assay to work with a wider array of geminiviruses and plants.

We are also studying carrot light root disease, a problem of early fall planted carrots grown in the desert regions of California. During the past year, we have shown that the disorder is not caused by lettuce infectious yellows virus, as was previously thought. Our carrot variety field trials showed that all of the 25 varieties tested had some naturally occurring incidence of this disease. We are currently investigating the possible role of whitefly feeding in this disease.

INVESTIGATOR'S NAME (S): Gary Elmstrom

AFFILIATION & LOCATION: University of Florida, IFAS, Leesburg, FL.

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: 1991 - 1992

In the Fall of 1991, a number of cultigens (varieties and breeding lines) of squash, *C. pepo* and *C. moschata*, were planted in the field and degree of leaf silvering was noted. Silvering of each plant was rated from 0 = no silvering to 5 = severe silvering. Whitefly populations were only moderate and a number of lines were completely free of silvering. Most of those that were free of silvering were *C. moschata*. In the Fall of 1992, 36 cultigens were planted in the field. Again, whitefly populations were only moderate and leaf silvering was not severe. However, a few lines had substantially less leaf silvering than the control varieties.

INVESTIGATOR'S NAME (S): N. J. Gawel and A. C. Bartlett

AFFILIATION & LOCATION: USDA-ARS-Western Cotton Res. Lab., Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: May 92 - December 92

Randomly Amplified Polymorphic DNA (RAPD) is a technique that uses the polymerase chain reaction (PCR) to enzymatically amplify arbitrary segments of DNA. The relative speed and ease with which these amplified regions, or RAPD markers, can be produced make them suitable for a number of applications, including genetic mapping, studies of population genetics, and DNA fingerprinting.

We used RAPD-PCR to examine differences in DNA structure between the poinsettia and cotton strains of *B. tabaci*. All twenty of the RAPD primers tested distinguished readily between the cotton and poinsettia strains. DNA extracted from individual eggs and nymphs showed similar differences. Genetic similarity statistics indicate that these two strains of B. tabaci were no more closely related to each other than to bayberry whitefly (*Parabemisia myricae*) or bandedwinged whitefly (*Trialeurodes abutilonea*). Previous comparisons of these two insect strains have documented areas of extreme similarity (morphology, RDNA sequences) and extreme dissimilarity (disease characteristics, host range, honeydew production, egg production and esterase patterns). Our results, too, find areas of similarity and differences, but the relatively small similarities and the magnitude of the differences provide no clear evidence to include the poinsettia and cotton strains under the same specific designation. However, before a consensus determination of the taxonomic relationship between these strains can be made, results from other genetic, morphological and physiological examinations will have to be compared.

RAPD-PCR was also used to examine populations of *B. tabaci* from Turkey, Egypt, Mexico, Oman, India, Zimbabwe, Japan, The Netherlands, Arizona, Georgia and Mississippi. Ten primers were used to generate molecular markers which were then analyzed by principal component analysis. The principal component model accounted for over 70% of the variability in the data set. The *B. tabaci* collected in the U.S., Egypt, Mexico Japan and The Netherlands were very similar and clustered tightly. Insects from Turkey, India and Zimbabwe exhibited characteristics that caused them to cluster apart from the U.S. group in semi-distinct groups. Some insects from Mexico did not cluster with other Mexican whiteflies. These abberant types exyhibit a greater similarity to the "A" strain than to other insects examined.

INVESTIGATOR'S NAME (S): Raymond J. Gill

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: January - October 1992

Since January 1992, an indepth morphological study of specimens of both the "A" and "B" strains of the sweetpotato whitefly was undertaken. This study involves two phases, a morphometric analysis of the vasiform orifice structures found in the pupae, and a very careful mapping of the setal and pore arrangements and other morphological landmarks of the dorsal surfaces of the pupal cases.

The morphometric analysis produced such widely scattered loci as to be unusable in separating the two strains. The careful mapping of pore and setal locations showed that these features are nearly identical in the two strains, and that there is an unusual movement or disappearance of some dorsal and marginal setae in the two strains, probably due to host or other environmental influences. However, it was found that a certain submarginal seta is apparently absent from the "B" strain as often as 95% or more of the time, whereas this setae is nearly always present in the "A" strain, and is present also in the type material of *Bemisia tabaci* and the type material of *Bemisia poinsettiae*. The absence of this seta in the "B" strain does not appear to be host related, but what other environmental or biological forces are affecting its presence or absense is unknown at this time. Since the presence or absence of this seta is not 100% in all cases, and since the seta is extremely small and especially hard to locate in specimens that have many enlarged dorsal setae and a very convex profile, it is not knowm at this point whether this character alone or in combination with other characters can be used practically in separating the two strains.

A study of other *Bemisia* species and those forms thought to be closely related has begun. This study should require about five years of intensive study, since charting the morphological structures and illustrating them will take time. It will also require the acquisition of loans from various foreign museums, a process that will also take time.

Based on findings so far, the locations and placement of the pore/porette combinations in *Bemisia tabaci* indicate that it is rather distinct from most of the other *Bemisia* species. Only three other species so far have a similar pore/porette combination: specimens of what are probably *Bemisia graminus* from Pakistan, an undescribed *Bemisia* from Sudan on grass, and a possibly undescribed species from the Gamblers Islands in the South Pacific. Based on the pore/porette combinations and the ommatidial arrangement in the adult eyes, the other common *Bemisia* species that are occasionally economic, including the *afer/hancocki* complex from Africa, *tuberculata* from Brasil and *berbericola* from the U.S., are apparently not that closely related.

INVESTIGATOR'S NAME (S): Donald L. Hendrix

AFFILIATION & LOCATION: USDA-ARS-Western Cotton Research Lab, Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: January - November 1992

Techniques have been developed to analyze the chemical composition of honeydew formed by the sweetpotato whitefly (SPW) feeding upon cotton leaves. In these analyses, the sugars in this mixture are separated by HPLC as anions using an eluant of 200 mM NaOH and a gradient elution of 0 to 0.5 M sodium acetate. Using this gradient HPLC technique it has been found that SPW honeydew from the cotton plant is a highly complex mixture typically involving at least 30 sugar components, ranging in size from monosaccharides to approximately DP12. Interestingly, this diverse array of sugars is entirely created (presumably within the SPW gut by transglycosylation) from approximately 0.5M sucrose in cotton phloem sap at an extremely rapid rate. Analyzing honeydew from SPW feeding upon various artificial diets has established some relationships between the developmental stage of the insect, the diet composition and the sugar components in the honeydew. The honeydew of SPW is substantially different from that of other homoptera and somewhat different from the *Bemisia* 'A strain' feeding upon cotton. SPW honeydew is unique among similar homopteran excretions in that it contains approximately 40% trehalulose (0-α-D-glucopyranosyl(l$\rightarrow$l)D-fructose]. Unlike honeydew from other homoptera, SPW honeydew contains a very small percentage of reducing sugars and the major component, trehalulose, is poorly reducing. This fact means that tests based upon the copper ion (i.e., Bennedicts' and Fehling's) are not suitable for the detection of honeydew-contaminated (i.e., 'sticky') cotton fiber. Sugars in this mixture consist of three distinct groups: polyols and small non-reducing oligosaccharides (trehalose, inositol, etc.), small saccharides (glucose, fructose, trehalulose, melezitose, etc.) and oligosaccharides larger than DP3. A number of the oligosaccharides in this mixture have unusual structures, including a trisaccharide based upon trehalose which is found nowhere else in nature.

A series of enzyme preparations have been examined in field experimentation to determine whether this honeydew can be removed from honeydew-contaminated cotton fiber during harvest. One of these enzyme preparations tested has been found to reduce honeydew sugars on the lint but the requirement for maintaining lint water content below 13% during enzyme application remains an obstacle to this approach to sticky lint cleaning.

INVESTIGATOR'S NAME (S): Dr. Marilyn A. Houck

AFFILIATION & LOCATION: Texas Tech University

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: June 1992 - June 1993

This project undertakes a multivariate morphometric statistical analysis of size and shape in *Bemisia tabaci*. The collection, preservation and mounting of specimens from various counties of the world will be accomplished as well as the drawing and digitizing of the morphological forms. Collection of specimens is in collaboration with Dr. J. Brown, Department of Plant Sciences, University of Arizona and Dr. Nick Gawel, USDA, ARS PWA, Western Cotton Res. Lab., Phoenix, AZ.

The intent of the project is to interpret the geographic variation In morphology of the pest to determine its country of origin. The number and spread of morphotypes, and whether or not there is a species complex represented in the US. These findings will provide a better understanding of how to best approach the problem of foreign exploration for biological control agents and the better projection of control strategies.

Localities of specimens currently acquired for study

> Antigua, Benin, Cypress, Egypt, Guatemala, India (Vajapur), India (Parbani), Israel, Japan (Chiba), Japan (Osaka), Mexico (Siniloa, Sonoita, Sonora, Caborca), Nicaragua, Nigeria, Oman, Pakistan, Panama (Los Sanlos), South Africa, Sudan, Turkey (Adana), Uganda (Kampula), United Kingdom, USA [Florida, Arizona, California], Wageningen, Yemen, Zimbabwe (Kadoma).

INVESTIGATOR'S NAME(S): J. E. Leggett

AFFILIATION & LOCATION: USDA-ARS, Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED: 1991-1992

Studies were conducted to determine potential mating interactions of *Bemisia tabaci* (Gennadius) biotype A and B adults under laboratory conditions. Individual adult pairs of A and B biotypes were observed under the microscope with a video recorder. Adult male and female pairs of the same biotype exhibited typical mating behavior as described in the literature. When A males were paired with B females or B males with A females, typical side-by-side positioning occurred, as well as antennal contact. However, males in each case, did not extend their wing, or only partially extended it over females. Also, wing fluttering did not occur. One female of a biotype B male x A female cross produced 30 males and 0 females. One female of an A male x B female cross produced 12 males and 0 females. The cross of one male from the preceding cross to a B female produced 0 males and 12 females. Matings within biotype A produced 21 males and 23 females. Matings within strain B produced 42 males and 90 females. The results of these mating observations indicated that the two strains were not compatible or that no sperm was transferred.

INVESTIGATOR'S NAME (S): Hsing-Yeh Liu, James E. Duffus, S. Cohen

AFFILIATION & LOCATION: USDA-ARS, Salinas, CA and The Volcani Center, Bet Dagan, Israel

RESEARCH & IMPLEMENTATION AREA: Section B: Fundam·ntal Research, Behavior, etc.

DATES COVERED BY REPORT: October 1, 1992 - September 30, 1992

Preliminary crossing experiments between the "Al" and "B" biotypes of *Bemisia tabaci* from the California desert using virgin males and females in short breeding periods produced no detectable hybrids.

Limited analysis of field collected whiteflies from the desert region had indicated an almost complete shift in the population from the previously occurring "A" biotype to the newly introduced "B" biotype. The biotypes were known from previous work to differ in the suitability of various hosts for nymphal development. Thus it was of interest to determine in the laboratory how this shift in population took place. Equal numbers of males and females of both biotypes (25A males + 25A females + 25B males + 25B females) were enclosed in large muslin-covered cages.

An esterase isozyme analysis on polyacrylamide gels was made on the caged mixed population at approximately monthly intervals. Parent survivors and subsequent generation adults on most hosts were a mixture of the "A" and "B" biotypes, however, there were a substantial number of hybrids or segregates. Perhaps a breakdown of apparent reproductive barriers occurred during the prolonged mixing experiments.

Populations maintained on sweetpotato and bean shifted quickly to the "A" biotype, whereas, those maintained on broccoli and melon shifted to the "B" biotype. However, after 5 months, segregates or recombinations of the "A" and "B" biotypes as determined by isozyme patterns were present on all hosts.

An isozyme analysis of *Bemisia* from California ("A" and "B"), Florida, Texas, Nigeria and Israel indicates that these populations have the range of isozymes representative of the variations or segregates of the "A" and "B" populations. However, the Israel population had additional bands not present in populations from the other regions.

Recent analysis of desert populations indicate a mixture of "A's, "B's" and hybrids. Thus under the laboratory and natural field conditions these two populations do not remain distinct. It seems that host suitability plays a major role in the adaptability of whitefly biotypes to different regions. Manipulating hosts and/or biotypes through breeding may be useful in changing the predominant whitefly in a region.

INVESTIGATOR'S NAME (S): 0. Minkenberg, E.A. Bernays, and K. Bright

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: July 1990 - July 1991

Host Plant Preference, Adult Performance, and Diet Breadth in *Bemisia tabaci.*

We hypothesized that adult SPW females (strain B) are highly polyphagous because they directly benefit, i.e. have a higher fecundity and survival, from feeding on various host plants. In a replicated study newly emerged females from cotton were exposed to three plants for a week in greenhouse cages. Groups of ten females were subjected to each of four treatments: cotton, bean, ground cherry, and a mix of these plants. Fecundity in eggs per female (and % survival) were 10. 1 (32%), 11.8 (44%), 17.9 (58%), and 7.8 (49%), respectively. Means between treatments were not significantly different. Surprisingly, fecundity was low for the plant mix.

In a second experiment, similar in design to the first one, we examined other host plants; cotton, holly hock, poinsettia, and a mix of these plants. Fecundity and, in parentheses, survival were 5.1 (40%), 11.3 (62%), 19.5 (60%), and 8.8 (66%), respectively. Fecundity of whiteflies on poinsettia was significantly higher than fecundity on cotton, whereas holly hock and mix did not differ in their effect from the other treatments (ANOVA followed by Tukey SRT, $F = 3.4$, $P = 0.044$). Survival did not differ significantly between treatments.

These experiments give no suggestion that mixing is beneficial in SPW. In fact, the mixed plant treatments tended to give poor performance overall or reduced performance compared with the better plants. The possibility that preferences were induced on plants first experienced (independent of quality) was investigated using the same plants as in experiment 1.

We switched individual females ($N = 15\text{-}17$) from one plant to another once in a two week study. Fecundity on plant pairs was for cotton-cotton, 3.5 and 10.7, cotton-groundcherry, 6.5 and 14.6, groundcherry-cotton, 9.4 and 7.6, groundcherry-cotton, 11.3 and 11.9, respectively. Because there were no clear trends, induction of preference was not considered likely.

In conclusion, we did not find any evidence that individual SPW females increase their performance by feeding on a mix of host plants nor that induction of host plant preference occurs.

INVESTIGATOR'S NAMES: J. W. Neal, Jr., and J. E. Oliver

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: Feb.-Nov., 1992

The White Fly Pheromone. Preliminary Observations. Male sweet potato white flies that emerged from pupae that had been placed on an uninfested broccoli leaf failed to either search for or find a female cohort within a distance of 12 cm within 4-6 hr. Their cohorts on the original heavily infested leaf located and courted females within that time frame. The implication is that under these circumstances either the females did not produce a pheromone active over a distance of greater than one centimeter, or, for some undefined reason, the males were not responsive to it.

Gas chromatograph Approaches. Assuming that a pheromone, if produced, would be of adequate volatility to be amenable to GC, several experiments were conducted.

a. Newly emerged adults (groups of 20-100 males and females individually) were extracted with dichloromethane, and the extracts were carefully concentrated and analyzed. Somewhat more material was extracted from the (larger) females, but no components could be detected that were exclusively associated with a single sex.

b. Similar comparisons were made between newly emerged and more mature females. More material was extracted from the older females but again no components could be specifically identified with the newly emerged females (that should have been of optimum pheromone-producing age).

c. Filtered air was passed through glass chambers containing very large numbers (more than 100 mg in some cases) of mixed sexes of recently emerged white flies; exiting air was passed through trapping matrices which were subsequently examined gas chromatographically. No white fly-produced volatiles could be detected.

INVESTIGATOR'S NAME (S): Lance S. Osborne[1], Desmond R. Jimenez[2], Raymond K. Yokomi[2], Jeffrey P. Shapiro[2].

AFFILIATION & LOCATION: Univ. of FL., IFAS, Apopka[1], and USDA-ARS, USHRL, Orlando[2]

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY RESEARCH: December 1991 to December 1992

Comparison of B-biotype induced squash silverleaf (SSL) and plant growth regulator(PGR)-induced leaf silvering.

Foliar application of the PGRs chlormequat chloride (Cycocel®, CCC) and paclobutrazol (Bonzai®) induced leaf silvering in several cultivars of the Cucurbitaceae. All of the cultivars were susceptible to sweetpotato whitefly-induced squash silverleaf (SSL). The temporal development of the PGR-induced silvering was similar to SPW-induced SSL, but the interaxial silvering induced by the PGRs resembled genetically controlled silvering more than SSL. Leaf silvering, chlorophyll reduction, root mass decline, and the alteration of intercellular fluid protein expression are symptoms of B-biotype SPW-induced SSL[a]. Root mass, chlorophyll content, and blossom number were increased by CCC. Stem internodes were shortened by CCC, and there was no double- stranded RNA present, or alteration of the intercellular fluid proteins. Although the two types of silvering were different, PGR- induced silvering offers insight into the mechanism of B- biotype-induced phytotoxemias. CCC and Bonzai are gibberellic acid (GA) antagonists. Foliar application of GA (ProGibb® 4%) eliminated the silvering response to CCC and attenuated some symptoms of SPW-induced SSL. This indicates that part of the phytotoxic response to SPW feeding is due to altered GA metabolism. PGRs have been reported to inhibit or stimulate insect growth and development, depending on the host plant and the insect parasite. When offered a choice between CCC treated cucurbits and controls, B-biotype SPW initially showed no preference. Fourteen days after CCC treatment the egg density was 3 times higher on the CCC plants than on the controls. The potential of PGRs as adjuvants to SPW IPM programs are under study. Microhabitat manipulation to bolster natural enemy populations, bait trapping, and amelioration of SPW feeding disorders are being evaluated.

[a] Jimenez D.R., Shapiro J.P., and Yokomi R.K. Cytology and physiology of sweetpotato whitefly induced squash silverleaf. Physiological and Molecular Plant Pathology, Accepted 1992.

[b] Osborne L.S. and Chase A.R. Chlormequat chloride growth retardant reduces spider mite infestations of Hibiscus rosa-sinensis. Hort Science 25:648-650, 1990.

INVESTIGATOR'S NAME (S): Thomas M. Perring

AFFILIATION & LOCATION: Dept. Entomol., Univ. Calif. Riverside

RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: 1 April 1992 - present

Our laboratory is approaching the issue of relatedness between *Bemisia tabaci*, types A and B, with the working hypothesis that these are two species. Using the definition of species proposed by Diehl and Bush (1984) as "natural populations that are reproductively isolated from one another and that follow distinct and independent evolutionary paths" we are conducting two studies (crossing experiments and mating behavior studies) to address the reproductive isolation aspect and two studies (genetic distance analysis based on isozymes and PCR-based single primer amplification) to elucidate the evolutionary paths followed by the two whitefly types.

In our ongoing crossing experiments, we have yet to observe an female offspring in cross-matings between A and B types, suggesting reproductive isolation. As a follow-up to this work, we are conducting mating behavior observations using video recording equipment.

We have published our work on allozymes using isoelectric focusing techniques for distinguishing the strains of individual whiteflies (Perring et al. 1992). This research identified two enzymes, phosphoglucomutase, and phosphoglucose isomerase which are particularly useful for distinguishing the two whitefly types. With esterases, we found complex banding patterns in 5 tightly linked loci; we were unable to consistently interpret these patterns. These problems, in addition to the inducible nature of esterases, has steered us away from using this enzyme for strain determination. With our technique, we have sampled whiteflies from the US (Arizona, California, Florida, Georgia, and Texas), Egypt, Mexico, and Spain from a variety of hosts and have found only the two types.

Finally, we are using a polymerase chain reaction based assay known as single primer amplification to compare DNA fragments of the two whitefly types. We have seen promise with this technique for distinguishing whitefly types.

References Cited:

Diehl, S.R. & G.L. Bush. 1984. Ann. Rev. Entomol. 29: 471-504.

Perring, T.M., A. Cooper, and D.J. Kazmer. 1992. J. Econ. Entomol. 85: 1278-1284.

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: January 1992 to November 1992

The research on the whitefly-transmitted tomato mottle virus (Geminiviridae) is progressing on several fronts. Several laboratory and field experiments have been conducted over the past year by pathologists, entomologists and plant breeders with a unifying theme of reducing the impact of the virus on tomato yields.

Cloning and sequencing of tomato mottle virus (TMoV) has been completed and establishes TMoV as a unique virus, similar to geminiviruses from the West Indies (1). Experimental and natural host ranges of tomato mottle virus (TMoV) have been established, which reveal the virus to have a unique combination of hosts, dominated by species in the Solanaceae (2). One weed host, *Solanum viarum* (yellow tropical soda apple), has been identified and transmission to and from tomato confirmed. However due to the population distribution of *S. viarum* at this time we believe that TMoV exists in the agroecosystem primarily in tomato plants. TMoV was not detected in any of 3000 tomato seedlings which germinated from seed produced in early-infected tomato plants, suggesting that the virus is probably not seed transmitted. These experiments plus monitoring of commercial tomato fields strongly suggest that TMoV is maintained throughout the year in tomato and that the primary source of inoculum for tomato plants is infected tomato plants. The main source of inoculum for newly planted fields are abandoned fields or fields carried over from the previous season which support significant numbers of adult whitefly and TMoV-infected tomato plants. Tomato volunteers and infected transplants contribute a smaller amount of the primary inoculum.

Conventional breeding for TMoV resistance in tomato is continuing. Resistance from the wild species, *Lycopersicon chilense*, has been obtained and introduced into *L. esculentum* germplasm. In one promising *L. chilense* accession this resistance was estimated to be controlled *by* 2 or 3 recessive genes. Other accessions are under study. Our research project designed to develop resistance in tomato to the whitefly is discussed in more detail in Section E.

1. Abouzid, A., Polston, J. E., and Hiebert, E. 199-. The nucleotide sequence of tomato mottle virus, a new geminivirus isolated from tomato in Florida. J. Gen. Virol. (in press).

2. Polston, J. E., Hiebert, E., McGovern, R. J., Stansly, P. A., and Schuster, D. J. 199-. Host range of tomato mottle virus, a new geminivirus infecting tomato in Florida. Plant Dis. (submitted).

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: May, 1992 through December, 1992

This project involves morphological and ultrastructural studies of the whitefly, *Bemisia tabaci,* with respect to the localization geminivirus particles following acquistion of virions by adult whiteflies from infected plants. We are attempting to localize geminivirus particles in the whitefly vector using two strategies: in situ nucleic acid hybridization and immunoelectron microscopy using polyclonal antibodies directed against viral coat protein. Virtually nothing is known about the interactions of between geminiviruses and their whitefly vector. Initially, in an attempt to investigate differences between the "A" and "B" biotypes of B. *tabaci,* we investigated the external morphology of adult whiteflies with particular emphasis on the mouthparts. The morphological characteristics of the mouthparts suggest that the stylet of *B. tabaci* appears to divide into 3-4 sections at the distal end of the rostrum. The central portion appears to be a hollow canal. We are currently investigating the importance of this observation with respect to virus acquisition and transmission at the light and electron microscopy levels. In addition, ultrastructural studies of the digestive system are in progress relative to identifying the specific route by which the virus passes through the vector during the acquisition/ transmission processes.

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY RESEARCH: December 1991 to December 1992

Characterization of sweetpotato whitefly-induced intercellular fluid proteins.

Pathogenesis-related proteins (PRPs) are recognized components of plant defense response. PRPs often appear in diseased plants at locations remote from their site of induction and they have been associated with nonspecific induced resistance. Some of these proteins are sequestered in vacuoles while others are transported out of the cell into the intercellular fluid of the apoplast. When pumpkin plants *(C.pepo* cv. small sugar pumpkin) were infested with both A-biotype and B-biotype SPW, only the B-biotype induced squash silverleaf (SSL). The intercellular fluid from the silvered leaves of B-biotype-infested pumpkin plants contained two induced proteins (31K and 70K Mr); a prominent constitutively expressed protein (60K) was absent[1]. We examined the intercellular fluid protein (IFP) profiles from Senator squash and Dixie squash, and found similar alterations in the IFPs. Foliar application of the plant growth regulator chlormequat chloride (Cycocel®) caused leaf silvering similar to SPWinduced SSL; however, the IFPs from the silvered leaves were similar to those of controls. These data support the hypothesis that the alteration in IFPs from SSL are part of a specific response to B-biotype SPW infestation. Intercellular chitinases (28-30K Mr) and peroxidases (33K and 60K Mr) are recognized PRPs. Analyses of chitinase and peroxidase activity showed that both enzymes were reduced in the intercellular fluid extracts of the silvered leaves from SPW-infested plants. Peroxidase activity in native gels showed no alteration of isozyme distribution when silvered leaves were compared to controls. Two dimensional PAGE, HPLC purification, and sequence analysis of the induced proteins are in progress.

Jimenez D.R., Shapiro J.P., and Yokomi R.K. (1992) Cytology and physiology of sweetpotato whitefly induced squash silverleaf. Physiological and Molecular Plant Pathology, Accepted 1992.

INVESTIGATOR'S NAME(S): Don O. Vacek

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RESEARCH IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY REPORT: 7/92 - 11/92

Genetics diagnostics for *Bemisia tabaci* and its beneficials.

We have begun to use RAPD-PCR to identify genetic markers that will distinguish among geographic strains and species of *B. tabaci* and its beneficials. This new technique uses the polymerase chain reaction (PCR) to amplify random regions of the genome, i.e., randomly amplified polymorphic DNA (RAPD), and has been termed RAPD-PCR. The work is being done in collaboration with other geneticists and classical taxonomists in order to accomplish the following objectives: 1) fulfill project evaluation requirements by using genetic diagnostics to identify beneficials in samples collected before and after beneficials are released, 2) fulfill APHIS regulations by recording a genetic fingerprint that represents each undescribed biological control agent species or strain before field release, 3) enable effective foreign exploration by locating countries where the particular pest strain (as defined by genetics diagnostics) is found, 4) monitor strain integrity in the mass rearing laboratory where several strains of many beneficials may be in culture under one roof. Data obtained with only three primers indicate that the 12 geographic populations of *B. tabaci* that were available for analysis can be divided into six groups. Unique banding patterns distinguish the "A" and "B" biotypes (from Central and North America) and four geographic populations from Spain, Egypt, India, and Nepal from each other. RAPD banding patterns of geographic strains of the parasitic wasp species in the genera *Encarsia* and *Eretmoceous* are being assessed.

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RESEARCH & IMPLEMENTATION AREA: Section B: Fundamental Research, Behavior, etc.

DATES COVERED BY RESEARCH: December 1991 to December 1992

Definition of whitefly phenotypic variation; biochemistry, physiology, and characterization of B-biotype whitefly dsRNA.

Esterase isozyme analysis, total RNA, double-stranded RNA (dsRNA), and the induction of squash silverleaf (SSL) were used to evaluate SPW from Florida, Arizona, Texas, Mississippi, and California. SPW capable of inducing SSL were B-biotype by esterase analysis. All B-biotype SPW colonies contained dsRNA. Laboratory cultures of A-biotype SPW did not contain dsRNA or induce SSL. A-biotype SPW (California IV-81) did not acquire the ability to induce SSL after feeding on silvered pumpkin leaves or leaves colonized by B-biotype SPW. Progeny of the acquisition experiments were dsRNA negative and unable to induce SSL[1,2]. Work is in progress to clone the B-biotype SPW dsRNA.

Attempts to induce A-biotype SPW-mediated SSL in cucurbits preconditioned by high intensity long duration light failed. Only B-biotype SPW induced SSL.

A- and B-biotype adult SPW were confined in separate clip cages and allowed to oviposit on the same host leaf, on different host leaves, and on different plants. B-biotype immatures developed faster than the A-biotype. Development of the A-biotype was not accelerated on plants conditioned by B-biotype feeding. Seasonal variation in the developmental rate is under evaluation.

SPW endosymbionts were purified from adult insects using density gradient centrifugation. Morphologically similar prokaryotes were located in the mycetome of 3rd instar nymphs using transmission electron microscopy. Fractionated prokaryotes from the adults were small (0.5-2.0 gm) rod-shaped bacteria surrounded by a secondary membrane which is probably of host origin. The endosymbiont of the mycetome was more pleomorphic yet it exhibited the same secondary membrane, the same size, and showed a similar internal cell architecture.

[1] Yokomi R.K., Hoelmer K.A., and Osborne L. S. Relationship between sweetpotato whitefly and the squash silverleaf disorder. Phytopathology 80:895-900, 1990.

[2] Jimenez D.R., Shapiro J.P. and Yokomi R.K. Biotype-specific expression of dsRNA in the sweetpotato whitefly. Entomologia exp. et appl. Accepted 1992.

TABLE B. Summary of Research Progress for Section B - Fundamental Research - Behavior, Biochemistry, Biotypes, Morphology, Physiology, Systematics, Virus Diseases, and Virus Vector Interactions in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	Progress Achieved No	Significance
B.1 Studies of feeding behavior: sensory receptors, ultra-structure, morphology, digestive physiology; intra- and interspecific competition.	Begin studies of ultrastructure, morph-ology; analyze feeding and digestive processes; begin studies of para-meters influencing competition.	X		Extensive and detailed information is being developed on feeding, digestion, cuticular characterization and morphology which will provide a better understanding of the SPWF problem and potential avenues to exploit for management potential. Electron micrographs of SPWF mouthparts show 3-4 parts and an apparently single hollow central portion. Amylase identified in SPWF suggest other than phloem target feeding sites, plant histological studies show > 30% feed on other plant tissues. SPWF honeydew from cotton has at least 30 sugars apparently created from 0.5 m sucrose in phloem sap. On artificial diet, honeydew is related to SPWF stage and diet components. Enzyme degradation of honeydew appears promising. A and B SPWF wax glands similar, surface cuticular lipids have been characterized. Pupal setae location and movement appear different in A and B biotypes. Morphometric analysis is being studied to establish species origin.
B.2 Studies of bio-chemistry, physiology, nutrition, development and reproduction.	Identify temperature tolerances; begin study of host influences (i.e., water balance, osmotic concentrations, nutrients) on SPW; begin studies of nutritional physiology, reproductive physiology, ploidy level.	X		Rates of water loss (10%), and oxygen consumption for A and B biotypes were similar. Thermal maximum thresholds about 52°C. An artificial diet developed supports adults for 2 weeks, 1st instar nymphs 4-7 days. Physiological similarities between biotypes exist. A defined artificial diet would be a major breakthrough for research and practical applications of mass rearing.
B.3 Studies to discover and analyze diagnostic characteristics of SPW, including component taxa, and to determine biological and genetic basis for development of biotypes, host races, and species, genetics and genetic diversity. Develop dsRNA and cDNA probe.	Collect SPW taxa and characterize their validity using morphological, molecular, biochemical, and biological studies to distinguish genetically different populations; develop voucher protocol for preservation of morphological and mole-cular information; establish centralized molecular services.	X		Recent data indicate biological and genetic differences exist between A & B populations. Additional data are needed to establish consensus with regard to species status. DNA structure analysis showed distinct differences between whitefly species and SPWF A and B biotypes. Esterase analysis of SPWF collection at many locations in the world show B biotype is widely distributed. ACHE enzyme systems in A and B are different. rRNA analysis of A and B types suggest they are conspecific. Isoelectric focusing techniques used to analyze SPW from various locations in US, Egypt, Mexico and Spain identified only 2 SPWF types (A and B). One study in contrast has identified A, B and Hybrids. Unique dsRna has been associated with the B-biotype."

TABLE B - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
B.4 Develop systematic analysis of the genus *Bemisia* utilizing various methods.	Begin analysis of all species of *Bemisia* using at least morphological and DNA sequence analyses; develop collecting and preservation protocols; identify sources worldwide and begin collecting material for analysis.	X		APHIS, ARS and State experiment station scientists have active programs for collecting SPWF and the associated natural enemies at many locations throughout the world. This effort is expected to intensify and provide base of material for study and analysis and practical application.
B.5 Identify and define SPW toxicogenic effects.	Characterize toxicogenic effects, cytology and EM.	X		Research results show promise for explanation of plant physiological syndromes associated with SPW infestations. A method of overcoming the effects may be revealed. Plant growth regulator-induced silvering in cucurbits similar to SPWF-induced silvering, but rootmass, chlorophyll and intercellular fluid expression was different. Gibberellic acid overcame PGR-induced symptoms and SPWF-induced silvering, suggesting GA modification from SPWF feeding. B biotype only induces silvering.
B.6 Characterize SPW endosymbiote (SPWe) influence on metabolism, host range, and biotype formation.	Treat SPW with antibiotics and determine effects on growth, development and reproduction.	X		Endosymbionts from A- and B-biotype SPW as well as several other whitefly species have been grouped according to ribosomal RNA sequences; further characterization of their contributions to SPW physiology are needed. Rod-shaped endosymbionts purified from adult SPW were morphologically similar to prokaryotes localized ultrastructurally in the mycetomes of third instar nymphs.
B.7 Investigate etiology of diseases; biological and molecular characterization of causal agents; develop understanding of relationship; molecular probes for viral diseases; diagnostics and resistance; virus-vector specificity and interactions.	Collect and establish pure cultures; initiate transmission studies and biological characterizations, cloning and purification for these studies and antibody production, screening for resistance.	X		Morphological mouthpart structures are being studied in relation to virus acquisition and transmission. Cloning and sequencing of tomato mottle virus completed, virus is unique. One weed host found, apparently exists primarily in tomato. Biological and molecular characterization of geminiviruses have been initiated. A hybridization system for identifying some geminiviruses has been developed. Also, geminivirus acquisition and transmission using nucleic acid hybridization and immunoelectron microscopy is being studied.

TABLE B - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
B.8 Study epidemiological parameters: vector population dynamics; disease thresholds; identify sources of inoculum, distribution, severity, and prevalence of pathogens. Correlate efficiency of transmission with biotypes, diversity and parameters of cropping systems.	Initiate study of transmission efficiency, vector population dynamics, fecundity studies, host reservoir studies. Survey problem areas to identify key virus isolates; develop transmission thresholds for viruses.	X		Carrot lightroot has been shown not related to infectious yellows virus. Squash lines screened show variable degrees of susceptibility to SPWF silvering. Hybridization profiles and partial host ranges have been generated for over 12 new viruses in tomato and pepper in the U.S. PCR-based methods are being developed to determine virus prevalence in existing cropping systems and to determine virus vector relations. New biotype specific viruses are being characterized (ToMoV, putative new geminivirus in crucifers) and vector efficiency is being evaluated with respect to previously characterized viruses (LIYV).
B.9 Study mating and oviposition behavior.	Study mating behavior in detail; determine possible role of sex pheromone; study role of mating in oviposition.	X		A and B biotype mating studies suggest reproductive isolation, but one study apparently identified hybrid populations. Attempts to identify a SPWF sex pheromone have been unsuccessful. A and B biotype mating studies suggest reproductive isolation "and data from studies in one laboratory indicate hybrid populations. Additional mating studies are needed between well defined populations." Attempts to identify a SPW sex phermone have been unsuccessful.
B.10 Determine factors influencing host plant selection and host acceptance.	Determine nature of physical, environmental, plant host, physiological cues involved; investigate extent of semiochemical mediation in host finding.	X		Sequential feeding periods on different hosts or exposure to different hosts did not affect SPWF fecundity or survival, suggesting no relation to preference. B biotype immatures developed faster than A's on the same host leaves, different host leaves or different cucurbit plants. Morphological characterization of host plants relative to SPW host selection should be expanded.
B.11 Identify plant nutritional and defensive responses to SPW and their effects on SPW and natural enemies.	Identify proteins, enzymes, and natural products induced in plants by SPW; examine influence of changes in nutrient levels on SPW and enemies.	X		Pathogenesis-related intercellular protein occurring in silvering phenomena appears related to SPWF infestations. A biotype development not accellerated on B biotype feeding conditioned plants.

RESEARCH SUMMARY

Section B: Fundamental Research, Behavior, etc.

Compiled by
J. K. Brown, D. R. Jimenez, and R. T. Mayer

B.1 Studies of feeding behavior: sensory receptors, ultrastructure, morphology, digestive physiology; intra and interspecific competition; and

B.2 Studies of biochemistry, physiology, nutrition, development and reproduction, genetics, and genetic diversity.

General ultrastructural studies on the sweetpotato whitefly *Bemisia tabaci* Genn. are in progress in several different laboratories. The external morphology of A- and B-biotype have been compared with an emphasis on mouthparts relative to virus-vector transmission. General ultrastructural studies of the digestive system in combination with *in situ* nucleic acid hybridization and immunoelectron microscopy are underway to characterize the acquisition and transmission of geminiviruses. Comparative ultrastructural studies of the external morphology and the secretory cells of the wax glands have shown that *B. tabaci* is similar to the greenhouse whitefly *Trialeurodes vaporariorum* West with respect to age-dependent wax production. Cytological studies on other cuticular glands are in progress. Endosymbiotes were purified from adult insects and compared to the prokaryote located in the third instar nymph from B-biotype SPW. Ultra-structurally, the two organisms were identical in size, internal architecture, and the appearance of the secondary membrane.

The surface lipids of *B. tabaci* were compared to those of *T. vaporariorum* and both species were found to contain very small amounts of saturated hydrocarbons. T. vaporariorum adults were characterized by C_{32} alcohols, C_{32} aldehydes, and C_{42} wax esters. *B. tabaci* were characterized by C_{34} alcohols and aldehydes, and C_{46} wax esters. In both species a C_{20} fatty acid is the major component of the predominant wax ester.

Honeydew from A- and B- biotypes of *B. tabaci* adults and nymphs that were fed on cotton have been analyzed. The excreta is a complex mixture composed of at least 40 different sugar components, some of which are unique to *B. tabaci* and some which are unique to the B-biotype. Sugars including trehalulose, a trehalulose derivative, polyols, nonreducing oligosaccharides, and a small amount of reducing mono-saccharides and oligosaccharides were detected. Oligosaccharides consisting of three to twelve mono-saccharide units were present in the honeydew of insects feeding on cotton (the phloem is composed of 0.5 M sucrose). It is believed that the complex array of carbohydrates are synthesized by the whitefly, despite an estimated transit time which was shown to be less than 2 minutes. Glycosidase mixtures have been evaluated as a means of eliminating the honeydew from cotton lint.

The presence of amylase activity in *B. tabaci* indicates that carbohydrates other than those in phloem sap may contribute to whitefly nutrition. Kinetics, substrate specificity, pI, pH optimum, weight-specific activity and stage-specific activity have been determined for SPW amylase. Evidence from histological studies indicate that a large percentage of the stylets of feeding whitefly nymphs are active in tissues other than the phloem. Chloroplast starch destruction at these feeding sites indicate that whiteflies derive some nutrients from the host mesophyll. An artificial diet has been developed to support adult and/or first instar feeding studies. Rates of honeydew production are significantly lower when SPW are fed on the artificial diet compared to controls fed on plant tissue.

The composition of the nonspecific esterase bands resolvable by native PAGE and used as population markers were characterized. The results indicate that there are differences in isoelectric point, size/charge isomeric relationships and the enzymatic activities of the acetylcholinesterases from A- and B-biotypes. Inhibition studies indicate that the isoform of acetylcholinesterase from the B-biotype may be altered.

B.3 Studies to discover and analyze diagnostic characteristics of SPW, including component taxa, and to determine biological and genetic basis for development of biotypes, host races and species; and to

B.4 Develop systematic analysis of the genus *Bemisia* utilizing various methods.

Morphological studies of the A- and B-biotype were focused on the pupal vasiform orifice, and the mapping of setae and pore arrangements. Morphometric analysis produced such widely scattered loci that the two strains could not be separated. One submarginal setae that is found in the A-biotype, the type material *Bemisia*, and the type material *Bemisia poinsettia* is absent from the B-biotype 95% of the time. Because of the small size of this setae and environmental forces affecting its expression it is not known if this character can be used to separate the two strains. A study of other *Bemisia* and those forms thought to be closely related was also initiated. Based on pore/porette combinations and ommatidial arrangement *B. tabaci* appears to be rather distinct and not closely related to other *Bemisia* of economic importance.

Multivariate, morphometric statistical analyses of size and shape in *B. tabaci* are underway for numerous populations previously typed by either nonspecific esterases and/or by random amplified polymorphic DNA (RAPD) analysis. These studies will allow for identification of morphological forms which can be useful in defining biotypic variation in populations obtained from different geographic sites and/or from different host plant species, and in determining the center of origin of *B. tabaci*.

Portions of the genes coding for ribosomal RNA (rRNA) from several whiteflies within the superfamily Aleyrodoidea were sequenced and compared to determine the genetic distance between the lineages. Based on the highly conserved 18S rDNA and the more variable D2 expansion segment of the 28S rDNA, *B. tabaci*, *Siphoninus phillyreae* (ash whitefly), and *Aleurodes spiraeiodes* (iris whitefly) appear to be descendant from an immediate common ancestor. *T. vaporariorum* showed sufficient genetic distance from other whiteflies to suggest descendence from a distinct and more ancient progenitor (Campbell et al.).

Polymerase chain reaction (PCR) has been applied to amplify and analyze arbitrarily targeted sequences in the whitefly DNA. RAPD markers and DNA fingerprints will be generated for use in population genetics studies. Both similarities and dissimilarities have been identified between the A- and B-biotypes. A principle component model generated several genetically different population clusters.

In another laboratory RAPD-PCR has been applied to twelve geographically isolated population yielding 6 distinguishable groups. A- and B- biotypes from Central and North America were separated and four other distinct banding patterns were generated for whiteflies from Spain, Egypt, India, and Nepal. The use of RAPD-PCR has been extended into the genetic cataloguing of indigenous and imported beneficial insects as well.

B.5 Identify and define SPW toxicogenic effects. Develop dsRNA and cDNA probe.

Esterase isozyme analysis, total RNA, double-stranded RNA (dsRNA), and the induction of squash silverleaf (SSL) were used to evaluate SPW from distinct geographic regions within the U.S.A. Colonies of B-biotype *B. tabaci* contained biotype-specific dsRNA and induced SSL regardless of their geographic origin. A-biotype were dsRNA negative, and unable to induce SSL even when plants were preconditioned by high intensity long duration light. The A-biotypes did not acquire dsRNA nor the ability to induce SSL after feeding on SSL affected plants. Cloning of the B-biotype-specific dsRNA is in progress.

Foliar application of the plant growth regulators chlormequat chloride (Cycocel®) and paclobutrazol (Bonzai®) induced leaf silvering in cultivars of the Cucurbitaceae that are highly susceptible to white-fly-induced squash silverleaf. The temporal development and cytopathic effects of the two types of silvering were similar but the general plant physiological responses were different. Cycocel and Bonzai are gibberellic acid (GA) antagonists. This indicates that part of the phytotoxic response to whitefly feeding is due to a B-biotype specific ability to alter GA metabolism.

B.6 Characterize SPW endosymbiote (SPWE) influence on metabolism, host range and biotype formation.

DNA sequences of the 16S ribosomal RNA (rRNA) isolated from the endosymbiotes of *B. tabaci* were compared to corresponding sequences from *S. phillyrea*, and *T. vaporariorum*. Sequence similarities indicate that the endosymbiotes from these three whiteflies are related and constitute a distinct lineage within the gamma subdivision of the *Proteobacteria*. The sequences from the endosymbiotes in both A-and B-biotypes of *B. tabaci* are unrelated to the endosymbiotes found in aphids or mealybugs. The eukaryotic genes for the 18S rRNA from the ash whitefly and both biotypes of *B. tabaci* were sequenced and compared to the sequence from the 16S rRNA of their respective endosymbiotes. The distance between each host and it respective endosymbiotes indicate that the evolutionary divergence in whitefly hosts and their endosymbiotes is congruent, and that the two biotypes are conspecific.

B.7 Investigate etiology of diseases; biological and molecular characterizations of causal agents; develop understanding of relationship; molecular probes for viral diseases: diagnostics and resistance; virus vector specificity and interactions; and to

B.8 Study epidemiological parameters; vector population dynamics; disease thresholds; identify sources of inoculum, distribution, severity, and prevalence of pathogens. Correlate efficiency of transmission with biotype, diversity, and parameters of cropping systems.

Biological and molecular characterization of many recently encountered and presently undescribed whitefly-transmitted (WFT) viruses is underway. Biological characterization involves studies of virus host ranges, experimental transmission characteristics, virus-vector interactions, and epidemiology.

A disorder of carrots, previously believed to be caused by lettuce infectious yellows virus, is under investigation and the possibility of a different etiology is proposed. *B. tabaci* is believed to be involved.

Detailed studies of tomato mottle virus (TMoV) from Florida are underway. The experimental and natural host range has been determined. The TMoV infects plant species within the Solanaceae and Leguminosae. The most important sources of virus inoculum are previously infected tomato fields. Breeding for virus resistance/tolerance is underway with *Lycopersicon chinenesis* serving as a potential source of resistance gene (s). The TMoV has been cloned and sequenced and is related to other new world whitefly-transmitted geminiviruses (Polston et al.).

Molecular studies being conducted include cloning and sequencing of viral genomic DNAs for geminivirus infected bean, cotton, pepper, tomato, and *Passiflora*, among others. Identification of open reading frames encoding viral proteins is underway. viral genomic DNA clones (or partial clones) are critically needed in the development of systems to detect and identify these new viruses. PCR methodologies are being applied to develop a systematic approach to virus detection and subsequent cataloging of these newly encountered viruses. Hybridization profiles are being compiled for all well characterized and newly occurring, uncharacterized. gemini viruses using a library of DNA probes for numerous whitefly-transmitted gemini viruses worldwide. This approach has allowed for the delineation of putative subclusters within the WFT geminiviruses indicating that a range of genetic variability is present within the subgroup. These proposed subclusters allow for postulation on the degree of relationship between viruses and subclusters, and suggests a possible strategy for identifying prototype or surrogate virus isolates for application to projects involving classical breeding or engineered virus resistance.

B.9 Study mating and oviposition behavior.

Several laboratories have conducted mating studies between the A-and B-populations of *B. tabaci*, and results are somewhat variable. In one case, crosses attempted between unmated virgin males and females yielded predominantly male progeny. However, female progeny were present at the rate of about 1-2 in 30 offspring. Characteristic nonspecific esterase patterns were used to confirm the genetic identity of parents

and subsequent progeny. In all cases, offspring exhibited an esterase phenotype identical to the female parent. Control AxA and BxB crosses yielded nearly equal proportions of both male and female, depending on the time of the year. These results may suggest a haplodiploid mechanism of reproduction for *B. tabaci*. Another laboratory which conducted similar mating experiments between the two biotypes observed only males among the progeny. They hypothesized that the A- and B-biotypes are reproductively isolated and thus may actually represent different species. When the phosphoglucomutase and phosphoglucoisomerase isozymes were used as population markers to differentiate *B. tabaci* populations from the U.S.A., Egypt, Mexico, and Spain, only two phenotypes were delineated. Specific factors contributing to the observed reproductive isolation have not been delineated.

In a third situation, a mass mating study was conducted between twenty-five A and B males and females each, respectively. A hybrid or segregation population was detected based on esterase analysis. similar characteristic hybrid esterase patterns were observed among *B. tabaci* collected from Israel, Nigeria, and the U.S.A. In addition several unique bands were found in the population from Israel. These data are inconstant with experiments conducted by two other laboratories in that reproductive isolation was not observed. Factors contributing to the development of hybrid populations have not yet been identified.

Preliminary attempts to characterize a whitefly pheromone using the behavior of whitefly pairs and gas chromatography indicate that females do not produce volatiles that are active over a distance greater than one centimeter.

B.10 Determine factors influencing host plant selection and host acceptance.

The hypothesis that the increased host-range of the B-biotype SPW increases its fecundity and survival rate was tested by allowing females to oviposit on individual hosts and mixed hosts. Results indicate that B-biotype fecundity was increased on poinsettia when compared to cotton, holly hock or a mixture of these hosts. otherwise there were no indications that mixed hosts or plant host preference improved fecundity or survival of the SPW.

Growth and development of laboratory populations of *B. tabaci* were compared on cucurbits. A- and B-biotype adult SPW were confined in separate clip cages and allowed to oviposit on the same host leaf, on different host leaves, and on different plants. B-biotype immatures developed faster than the A-biotype under all tested conditions. Development of the A-biotype was not accelerated on plants conditioned by B-biotype feeding. Seasonal variation in developmental rates are under evaluation.

B.11 Identify plant nutritional and defensive responses to SPW and their effects on SPW and natural enemies.

Pathogenesis-related proteins can be increased by stress, and disease. They are sequestered in vacuoles or transported out of the cell into the intercellular fluid (IF). The IF from silvered leaves of B-biotype-infested cucurbits contained two induced proteins (31K and 70K Mr) and a prominent constitutively expressed protein (60K) was absent. In the Cucurbitaceae chitinase (28-30K Mr) and peroxidase (33K and 60K Mr) isozymes are frequently induced as part of a host response to pathogens. Analyses of chitinase and peroxidase activity showed that both enzymes were reduced in the IF from SPW-infested plants. Characterization of these systemically induced proteins elicited in response to SPW damage offers fundamental information regarding, phytotoxicity and nonspecific induced resistance to pathogens (viral, fungal or bacterial).

C. Chemical Control, Biorationals and Pesticide Application Technology

Chairs: Nick C. Toscano and John Palumbo

Committee Members: J. Neal, D. Akey, P. Stansly, and D. Wolfenbarger

1. Abstracts
2. Table C
3. Research Summary

INVESTIGATOR'S NAME (S): D.H. Akey, T.J. Henneberry and C.C.Chu

AFFILIATION & LOCATION: USDA, ARS, Western Cotton Res. Lab., Phoenix, 85040

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORTS: August - September, 1992

A trial with candidates for chemical control of SPW were conducted at a site in Maricopa, AZ, with small plots (5 plots = 0.052 ac). Agents tested included: two pyrethroids, bifenthrin (Capture™) and fenpropathrin (Danitol™) with and without the organic phosphate acephate (Orthene™) as a possible synergist; two formulations of the insect growth regulator (IGR), Azadirachtin (Margosan-O™ and AD1000™); the IGR buprofezin (Applaud™); two non-phosphate compounds, amitraz (Ovasyn™) and imidacloprid (Confidor™ [Bay NTN 33893]), and a Cyclo-compound, endosulfan (Thiodan™). Data for mean egg numbers per cm^2 of leaf for the last four applications of 7 application showed significant control ($P \leq 0.01$) as percent reduction from a block of untreated plots as: pyrethroids with or without acephate -- 94.-to 96.%, amitraz -- 84%, azadirachtin -- 82%, endosulfan-- 82%, buprofezin -- 81%, and acephate 73.3 %. at $\underline{P} < 0.01$. Data for large immatures per cm2 of leaf for the last four of 7 applications showed significant control ($P \leq 0.05$) as percent reduction from a block of untreated plots as: pyrethroids with or without acephate -- 97-98%, buprofezin -- 99%, amitraz -- 98%, imidacloprid -- 97%, azadirachtin as AD1000 -- 96%, and endosulfan-- 96% For the first 3 applications, mean adult population per plot per cm^2 of sticky card was 13.47 ± 0.51 SE and ranged from 10.92 to 16.65 with no signifigant differences between treatments and controls. For the second 4 applications, the mean adult population per plot per cm^2 of sticky card was 22.17 ± 0.83 SE and ranged from 14.34 to 26.32 with no significant differences between treatments and controls by ANOVA. The large increase in the mean adult population present in the 2nd half of the test compared to the 1st half of the test (22.17 vrs. 13.47) was highly significant at $\underline{P} < 0.001$.

INVESTIGATOR'S NAME (S): D.H. Akey, T.J. Henneberry and C.C.Chu

AFFILIATION & LOCATION: USDA, ARS, Western Cotton Res. Lab., Phoenix, 85040

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORTS: August - September, 1992

A trial with candidates for chemical control of SPWF were conducted at a site in Maricopa, AZ, with large plots (5plots = 1.12ac) as, agents tested included buprofezin (Applaud™) and amitraz (Ovasyn™) with and without endosulfan (Thiodan™), the latter was also tested alone. For the last two of 5 applications, means of egg numbers were reduced by 69.9 to 92.3 % from control plots at $\underline{P} < 0.01$ for all agents and combinations tested with the two most effective treatments being buprofezin/endosulphan and amitraz/ endosulfan. For the last two of 5 applications mean numbers oflarge immatures per cm^2 of leaf showed significant control ($P \leq 0.01$) as percent reduction from adjacent control plots as: buprofezin, with or without endosulfan -- 99%; endosulfan -- 94%; amitraz with endosulfan -- 93%; and amitraz alone -- 67%. For the first 3 applications and the last two of the 5 application, means of adult populations were significantly reduced, by 4 of the 5 treatments (exception was amitraz), by 46.2 to 65.1 % from those in control plots at $\underline{P} < 0.01$ and $\underline{P} < 0.05$ for the first 3 and last 2 applications respectively. The large increase in the mean adult population per control plots per cm^2 present in the 2nd half of the test compared to the 1st half of the test (29.3 vrs. 13.95) was highly significant at $\underline{P} < 0.01$.

INVESTIGATOR'S NAME(S): [1]D.H. Akey, [2]J.W. Neal, [3]R. Severson, [4]M. Stephenson, [5]G. Pittarelli, and [6]G.Buta

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORTS: August - September, 1992

A detergent-like biosoap that breaks down the waxy coating of the cuticle of immature SPW was formulated from active compounds extracted from *Nicotiana gossei*, a plant found in Australia and a relative of the tobacco plant. Two trials were performed on the active extract. Both trials were conducted with 3 weekly applications late in the central AZ cotton growing season with DP 90 cotton with high levels of all lifestages of SPW (e.g., trial 2 had 13.7 immatures per cm^2 of leaf. Trial 1 was conducted at the Maricopa Agri. Center (MAC), Maricopa, AZ in 5 single-row plots 34 ft long. They were randomly distributed among 14 treatments (including untreated control plots among treated plots and untreated control plots in an untreated block) with one treatment per each of 5 replicates. Extract was applied at 0.51 lb ai/ac at 61 gal/ac. Percent reduction of SPW immatures was 94% compared with untreated controls in the untreated block. Trial 2 was conducted at WCRL, Phoenix AZ in single-rows plots 16 ft long, randomly distributed among 3 replicates with 4 treatments (including 3 control plots among the treated plots) and 3 control plots in as untreated check block adjacent to the treated plots for a total of 15 plots. The other two treatments included 2% V/V solutions of petroleum oil (SunSpray Ultrafine oil™, Mycogen Corp.) and potassium salts of naturally derived fatty acids (M-Pede™, Mycogen Corp. Compared with untreated control in the check block,highly significant percent reductions occurred :extract-- 78% , M-Pede™ --58 % and for SunSpray Ultrafine oil™ --65% ($\underline{P} < 0.01$, ANOVA and Duncan's MRT).

INVESTIGATOR'S NAME (S): J. G. Buta and G. W. Pittarelli

AFFILIATION & LOCATION: USDA-ARS-BA, Horticultural Crops Quality Lab, and Soybean and Alfalfa Research Lab, Beltsville, MD

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: October 1991 - October 1992

Some *Nicotiana* species were tested for insecticidal activity against the peach aphid and two-spotted spider mite to compare results with previous studies with the greenhouse whitefly (GHWF) and sweet potato whitefly (SPWF). Insecticidal activity had been found against the GHWF/SPWF with the following species: *N. gossei, cavicola, benthamiana, undulata trigonophylla, glutinosa, africana, and fragrans*. Activity against the aphid and mite were found with the first three *N.* species. Isolation of the active compounds from *N. gossei* was done using the whitefly nymph bioassay of J. Neal, Jr. (Beltsville).

The structures of the active compounds were determined to be series of 6'-acetyl-2,3-diacylsucrose and 1',6'-diacetyl- 2,3-diacylsucrose esters. (See Phytochemistry, In Press). A patent concerning the use of *N. gossei* sucrose esters as biological pesticides was applied for by ARS on May 1, 1992.

N. gossei seed was supplied by us to M. Stephenson and R. Severson (ARS, Georgia) for use in field studies.

Preliminary results indicate that the quantities of *N. gossei* sucrose esters produced per plant can be increased by production of artificial tetraploids using a colchicine treatment. Experiments in this area are continuing in collaboration with R. Severson (Athens, GA).

Efforts are underway to incorporate the genes responsible for the specific *N. gossei* sucrose esters into the germplasm of *Nicotiana tabacum* with the goal of increasing the yield of sucrose esters in commercially useful cultivars (GWP).

Utilization of *N. gossei* plants in the greenhouse to control SPWF or GHWF populations is being investigated.

Assays to investigate the activity of various *Nicotiana* extracts against the adult GHWF have been developed and appear promising as rapid bioassays.

INVESTIGATOR'S NAME (S): G. D. Butler, T. J. Henneberry, P. S. Stansly, and D. J. Schuster

AFFILIATION & LOCATION: USDA-ARS-Western Cotton Research Lab, Phoenix, AZ, and the University of Florida, Bradenton

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: March - May 1991

Efficacy against the sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius), of an insecticidal soap, two horticultural oils (one vegetable and the other petroleum based) and 15 detergents was evaluated under greenhouse conditions. Applications were directed to the underside of infested zucchini squash, tomato, or poinsettia leaves. Live nymphs were distinguished by their ability to deposit honeydew on water-sensitive paper held in contact. With the exception of 3 detergents, all materials evaluated at 1% concentration caused greater than 85% mortality of SPW nymphs compared to applications of water. Similar results with 2 detergents and an insecticidal soap were obtained on infested cucumber leaves treated in the field in Florida. Saf-T-Side (mineral) oil, Natur'l oil (vegetable) oil, New Day liquid detergent or M-Pede applied with a mist blower reduced numbers of SPW adults in heavily infested cucumber plots, although only Saf-T-Side oil resulted in a significant reduction of nymphs.

INVESTIGATOR'S NAME (S): Richard B. Chalfant and Harold R. Sumner

AFFILIATION & LOCATION: Georgia Coastal Plain Experiment Station, Tifton, GA 31793--0748

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: Progress Report for Years 1991 & 1992

Control of the Sweetpotato Whitefly on Bell Pepper, Tomato, Watermelons, and Squash with Insecticides, Biorationals and New Equipment Technology

The B-strain of the sweetpotato whitefly has been a pest in Southcentral Georgia since 1989 causing significant damage to late-season vegetables, especially cucurbits and Solonaceous crops. It causes "silverleaf" in squash. In 1991 sprays of imidcloprid (0.15 & 0.3 Lb [AI]/Acre) or endosulfan (1.0 Lb [AI]/Acre) mixed with 2% Saf-T-Side crop oil gave significant reduction of silverleaf on straightneck squash. Effectiveness was limited by spray coverage. Sprays were applied at a pressure of 50 psi in 50 gal water per acre using 3 Spraying Systems TX-18 nozzles per row. In 1992 sprays with hydraulic equipment were applied at 200 psi in 50 gal water per acre using 5 Albuz (1 mm diam) nozzles per row. Granules of imidcloprid were applied in furrow at planting (squash, only). Endosulfan, (0.75 or 1.0 Lb [AI]/Acre) mixed with 0.75% or 1.0% oil (JNS Stylet Oil or Saf-T-Side) consistently gave significant reduction of silverleaf on squash and whitefly eggs and nymphs on tomatoes and watermelon. Imidcloprid (0.045 gm/m, in furrow) gave effective reduction of silverleaf for 4 weeks but not for 6 weeks after planting. Other promising treatments were buprofezen (0.8 Lb [AI]/Acre) and amitraz + buprofezen combination (0.25 + 0.38 Lb [AI]/Acre). In another field test on squash, biorational extracts from species of Solonaceae had significant activity against whitefly adults and resultant oviposition and nymphs.

Performance of a hydraulic boom sprayer (3 TX-18 nozzles/row, 30 gpa), Berthoud air boom (30 gpa) and electrostatic air assist sprayer (3 gpa) was compared on squash evaluating reduction of silverleaf with two rates of endosulfan and endosulfan + Saf-T-Side mixtures. With 1.0 Lb [AI]/Acre of endosulfan, the electrostatic and conventional sprayers performed significantly better than the Berthoud. (12, 25, and 74 percent silverleaf, resp.). With 0.5 Lb [AI]/Acre endosulfan, the hydraulic boom sprayer performed better than the electrostatic and Berthoud (26, 73, and 93 percent silverleaf, resp). Addition of 2% Saf-T-Side significantly improved performance of the Berthoud but not the other two sprayers. Saf-T-Side alone was not significantly different from the untreated check (100% silverleaf) with all three sprayers. The electrostatic sprayer was significantly poorer at the lower (0.5 Lb [AI]/Acre) than at the higher (1.0 Lb [AI]/Acre) rate of endosulfan. There were no significant differences between rates for the other two sprayers.

INVESTIGATOR'S NAME (S): Laurence D. Chandler, Harold R. Sumner and Gary A. Herzog

AFFILIATION & LOCATION: USDA-ARS-IBPMRL and University of Georgia Coastal Plain Experiment Station, Tifton, GA 31793

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: 1992

Low numbers of sweetpotato whitefly were observed on peanuts throughout the summer-fall growing season. Two insecticide applications (9-16, 10-1-92) were made to 'florunner' variety peanuts using a Berthoud cannon air boom sprayer equipped with two air sheer nozzles (blue 0.06" dia) per row operating at 15 psi and calibrated to deliver 20 gpa of water. All insecticide treatments reduced whitefly numbers, in varying amounts, immediately after application. Whitefly populations increased 7 to 10 days after each application. Application of thiodan 3EC (1.0 lb ai/ac) resulted in the largest and most consistent reduction in the number of sweetpotato whitefly nymphs and eggs throughout the evaluation period. Applaud (0.38 lb ai/ac) also provided consistent reduction of nymphs and eggs. Application of capture 2EC (0.08 lb ai/ac) + orthene 90S (0.05 lb ai/ac) or danitol (0.02 lb ai/ac) + orthene 90S (0.05 lb ai/ac) resulted in useful reductions of whitefly eggs. Danitol + orthene also reduced the number of nymphs on leaves within 48 hours after application. However, adults returned and large increases in the numbers of nymphs per leaf were observed within 7 days after treatment. Evaluation of insecticide efficiency using yellow cards was difficult. No consistent reduction in whitefly adult numbers/card were noted in any treatment.

Effectiveness of chemigation methodology for sweetpotato whitefly control on squash was evaluated during the fall growing season. Three plots (0.33 ac quadrants of a single tower center pivot irrigation system) were planted in 'yellow crook neck' variety squash. Insecticides (either BAYNTN 33893 at 0.043 lb ai/ac or asana 0.66 XL at 0.05 lb ai/ac) were chemigated on 9- 29, 10-6 and 10-22-92. Applications were made to a single plot using Nelson R-30 sprinklers calibrated to deliver 0.10 inch/ac of water. One plot was used as an untreated control. Following each application a reduction in the number of whitefly adults/card, nymphs and eggs per plant were noted in both insecticide treated plots. Additionally, plants treated with asana supported fewer nymphs and eggs than did plants treated with BAYNTN 33893.

INVESTIGATOR'S NAME(S): C. C. Chu, T. J. Henneberry, and D. H. Akey

AFFILIATION & LOCATION: USDA-ARS, Brawley, CA & Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: March - June 1992

Foliar applications of Aliette, Applaud, Bay NTN 33893 (NTN), Capture, Danitol, Fenoxycarb, M-Pede, Margosan-O, Monitor, Ovasyn, Thiodan, a mixture of Capture and M-Pede, a mixture of Capture and Monitor, a mixture of Danitol and Monitor, and a mixture of Fenoxycarb and M-Pede were evaluated for sweetpotato whitefly (SPW) control on spring cantaloupe. Untreated plots were controls. Foliar applications were biweekly on six occasions from March 17 when plants were in the cotyledon stage to June 5 when melons were harvestable. Except during the cotyledon stage, the fourth expanded leaf from the vine terminals was picked from each of 10 plants in each plot one day before and two days after each chemical application. One leaf disc (11.34 cm^2) was punched from each leaf and eggs and large SPW nymphs counted.

Acceptable SPW control was obtained with NTN (0.38 lb ai/ac), a mixture of Capture (0.08 lb ai/ac) and Monitor (0.75 lb ai/ac), and a mixture of Danitol (0.2 lb ai/ac) and Monitor (0.75 lb ai/ac). Plants in plots treated with these materials were healthier and more vigorous than plants in plots treated with any of the other chemicals and the plants in untreated control plots. NTN-treated plots produced the highest number of marketable cantaloupes (11,100/ac) followed by 10,300 and 9,300 marketable cantaloupes from plots treated with Danitol and Monitor, or Capture and Monitor, respectively. Average production from 1988 to 1991, before epidemic SPW outbreaks, was greater than 24,000 melons/acre. Mean numbers of SPW eggs (32.74/cm^2) and large nymphs (5.74/cm^2) were also significantly reduced compared to plants in plots treated with any of the other chemicals or the untreated control plots. SPW were not found in Spring cantaloupes until mid-April. Research in 1993 will be focused on early planting under plastic mulch to determine the effect on early plant growth and isolation of young plants to escape heavy SPW infestations.

INVESTIGATOR'S NAME(S): C. C. Chu, T. J. Henneberry, and D. H. Akey

AFFILIATION & LOCATION: USDA-ARS, Brawley, CA & Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: March - August 1992

Foliar applications of Aliette, Applaud, Azatin, Bay NTN 33893 (NTN), Capture, Danitol, Fenoxycarb, M-Pede, Margosan-O, Orthene, Ovasyn, a mixture of Capture and M-Pede, a mixture of Capture and Orthene, a mixture of Danitol and Orthene, a mixture of Fenoxycarb and M-Pede, and sidedress soil application of Temik at early square or applied at layby were evaluated for sweetpotato whitefly (SPW) control. Untreated cotton plots were controls. Foliar applications (9) were made biweekly from April 15 (cotyledon stage) to August 5 when plants were defoliated by SPW infestations. The fourth mature leaf on the main stem was picked one day before and two days after each foliar application from 10 plants in all plots. Eggs and large 3rd and 4th stage nymphs were counted on each of 11.34 cm^2 leaf disks from each leaf in each plot.

Results showed that the mixture of Danitol and Orthene at 0.2 and 0.5 lb ai/ac, respectively, gave the best control. Average lint yield was 1232 lb/ac as compared to 551 lb/ac from untreated plots. Mean numbers of SPW eggs and large nymphs were 9.6 and 1.6/cm^2 of leaf area for samples taken June 9 to August 21, compared to 20.7 eggs and 4.5 large nymphs/cm^2, respectively, from untreated control plots. Cotton foliage of Danitol-Orthene-treated plots remained green and turgid during the growing season while leaves of plants in plots treated with other chemicals and the untreated controls became desiccated and abscised. Foliar applied mixtures of Capture and Orthene, and Capture and M-Pede gave marginally effective control with lint yields of 976 and 904 lb/ac, respectively.

INVESTIGATOR'S NAME(S): Wayne Coates, John Palumbo, Theo Watson

AFFILIATION & LOCATION: Univ of Arizona, Dept. of Agricultural Engineering, Tucson, Univ of Arizona, Dept. of Entomology, Yuma and Univ of Arizona, Dept. of Entomology, Tucson

RESEARCH AND IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: July 1, 1992 - October 31, 1992

Trials were conducted in cotton, cauliflower and lettuce to determine the effectiveness of electrostatic sprayers for controlling whitefly populations, as compared to conventional spray methods. Two electrostatic sprayers were used for the trials. One unit employs oil as the carrier, the other water. Because of the difficulties associated with finding chemicals that were compatible with the oil carrier sprayer, its evaluation was limited to cotton. Chemical rates of 0.5X and 0.25X were applied with the electrostatic sprayers in addition to the IX rate. For the cauliflower trials, an air assisted sprayer was also included in the test program.

Coverage was evaluated using the leaf washing technique developed by Jim Carlton at College Station, Texas. In cotton, leaves at the top and at the bottom of the plant were selected for the washing trials. For the cauliflower, a single height was used initially, with two heights chosen as the plants increased in size. Water and oil sensitive papers were placed on the cotton plants at two heights, on the dorsal and ventral sides of leaves. These were scanned to determine percent coverage and droplet size distributions. Analysis of the leaf washing data and spray paper data are not yet complete. Preliminary analysis of the efficacy information for cotton showed no statistically significant differences among sprayer treatments, even at reduced application rates.

INVESTIGATOR'S NAME (S): Bastiaan M. Drees

AFFILIATION & LOCATION: Texas A&M University System

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: 1992

A number of trials have been conducted to evaluate the efficacy of various treatment programs for the sweetpotato whitefly on greenhouse and outdoor ornamental plants. The efficacy of at-plant media treatments using aldicarb (Temik® 10G) and imidacloprid (Merit®) was documented. In addition, foliar treatments with imidacloprid or cyfluthrin (Tempo®) on a weekly basis were compared to a single media drench with imidacloprid.

A large study was undertaken to document "predisposition" to contact sprays (fenpropathrin or Tame® plus acephate or Orthene® 75S) by a preventive treatment program using insect growth regulators (azadirachtin or Margosan-0® and fenoxycarb or Ensigar® 25WP).

Comparative effects from 3-4 days sprays using *Beauvaria bassiana* (Naturalis®) and *Paccilomyces fumosoroseus* (Grace-Sierra) are in progress.

All trials are controlled. Treatment design uses non-replicated blocks of 25 to 50 plants receiving various treatments/treatment programs. Whitefly infestations are monitored by counting number of adult or nymph infested leaves out of 5 randomly-selected leaves per plant from 5 to 20 plants. Results are analyzed using ANOVA and Duncan's MRT ($P < 0.05$). Final reports are in preparation.

INVESTIGATOR'S NAME (S): Osama El-Lissy and Larry Antilla

AFFILIATION & LOCATION: Boll Weevil Eradication Program

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: September - October 1992

Control of the sweetpotato whitefly (SPWF), *Bemisia tabaci* (Gennadius) by treating Pima cotton, *Gossypium barbadense* L., field edges was evaluated at Marana, AZ. Five pairs of 24 Ha fields were selected as experimental plots. Each pair of fields was managed by the same grower and the cotton was approximately in the same stage of development. Aerial applications of insecticides were made with a Piper Pawnee airplane. A 13.7 m swath was treated on the periphery of 1 field of each pair. The first two treatments included Asana XL (228ml/Ha) and Orthene 90 (187g/Ha) mixed with water (19 l/Ha), the third and fourth treatments included Capture 2EC (112ml/Ha) and Orthene (187g/Ha) mixed with water (19 l/Ha). Insecticides where applied once every six days. The untreated fields of each pair served as controls.

Pretreatment counts of adult SPWF were made using an oil-coated black pan 24 h before the first application and at 48 h intervals thereafter for 4 weeks. Counts were made on rows 3, 12, 21 and 30 (the distance rows was 1.0 m) at 3 locations on all four sides of each treated and untreated field. Counts were also made on rows in the center of the fields. Effects on immature SPWF were determined by taking the 6th leaf from the top of the main stem from five plants in each location 24 h before the first application and at weekly intervals thereafter. Number of eggs and immatures (all stages) were counted on the underside of $1cm^2$ leaf discs on each side of the main vein.

The mean number of eggs on $1cm^2$ leaf discs rows 3, 12, and 21 was not significantly different in pre and post treatment samples. Numbers of eggs in untreated fields increased by 42% in row 3, 171% in row 12 and 194% in row 21. The mean number of SPWF nymphs in rows 3, 12, and 21 was not significantly different in pre and post treatment counts in treated fields but in the untreated fields increased by 957% in row 3, 325% in row 12 and 867% in row 21. The number of SPWF adults were significantly less in all rows of treated fields compared to untreated fields in which the number significantly increased. Number of SPWF adults in the center of treated fields were not significantly different before and after insecticidal application but SPWF adults significantly increased in the samples in the untreated fields.

These results indicate that the numbers of SPWF adults and immatures can be significantly reduced by treating only the periphery of cotton fields.

INVESTIGATOR'S NAME(S): E. Franz and J. B. Carlton

AFFILIATION & LOCATION: USDA-ARS, Aerial Applic. Res. Unit, College Station, TX

RESEARCH AND IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: April 15 - November 13, 1992

Software was developed to analyze images of spray deposits on spot cards which have been digitized with a low-cost, portable scanner. This technique permits evaluation of the quality of spray applications and provides quantitative data for developing relationships between application methods and efficacy. Percent area coverage, spot count/density, and spot size statistics are obtained. Two calibration methods have been developed. However, both are sensitive to color properties of the spots. This implies that the method may need to be calibrated for each spray mix.

The effects of airplane operating parameters (ie., treatments in SPW field studies) on aircraft wake and temporal spray deposits have been measured in a mature cantaloupe canopy and in small (unlapped) and large (lapped) cotton canopies. The results will further the understanding of spray application dynamics and provide a basis for future recommendations to enhance application efficiency.

Constant temperature anemometry was used to measure the effects of aircraft loading, airspeed, and height of flight on aircraft wake intensity. Increasing aircraft loading increased mean airflow by 48% and turbulence by 26%, decreasing airspeed from 115 to 90 mph increased mean flow by 64% and turbulence by 10%, and decreasing height from 15 ft to 5 ft increased mean airflow by a factor of 2.5 and air turbulence by 60% relative to ambient airflows. These results were used to select two aircraft speeds (90 and 115 mph) and 5 ft height of flight for comparison during *Beauveria bassiana* applications for control of SPW in cantaloupe and cotton.

Winglets (air deflectors - Chimavir Services, Israel) attached to an aircraft spray boom increased air turbulence levels by 20%. The initial downwash appeared to be increased and persisted for 4 to 5 seconds.

Leaf washers developed for studying spray deposition on plants performed well during extensive use for sampling deposits on upper and lower leaf surfaces in cantaloupe and cotton in Lower Rio Grande Valley research plots. Eight washers were constructed for use by ARS scientists at College Station and nineteen for scientists at other locations. These devices provided quantitative information on spray deposits on upper and lower surfaces of leaves in various parts of plant canopies and permitted comparisons of application techniques designed to improve targeting of spray materials for SPW control. A manual covering leaf washer operation, calibration, and potential errors was developed and provided to users.

INVESTIGATOR'S NAME(S): G. A. Herzog, H. R. Sumner, L. D. Chandler, R. F. Severson, and M. G. Stephenson

AFFILIATION & LOCATION: University of Georgia, and USDA-ARS, Coastal Plain Experiment Station,. Tifton, GA, and USDA-ARS, Athens, GA

RESEARCH AND IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: July 1 1992 - December 31, 1992

Evaluation of chemicals for control of SPW was made using a conventional hydraulic boom sprayer with drops using three TX-10 nozzles/row as per Sumner's report (these proceedings). Applications were made weekly beginning August 2, 1992. Samples of leaf tissue with immatures were made photographically and counts are still being made from these photos; thus results of these trials on immature stages of the SPW are presently unavailable. Results from adult counts on sticky cards indicate few differences among treatments. Numerically, mixtures of fenpropathrin or bifenthrin with acephate provided the best results. Bifenthrin or acephate applied alone did not perform as well indicating some additive or synergistic influence. In order of level of control according to the sticky card information, treatments could be placed in this order, from best: fenpropathrin, 0.2 + acephate, 0.5; bifenthrin, 0.08 + acephate, 0.5; buprofizen, 0.38; endosulfan, 1.0; bifenthrin, 0.08; imidaclorprid, 0.043 + Kinetic, 12 oz/100 gal; azidirachtin, 0.044; acephate, 0.5; untreated control; amitraz, 0.25; and fosethyl-al, 4.0. Information regarding the condition of the plants as a result of SPW damage following five of the applications indicated the following results in order of declining plant vigor: fenpropathrin + acephate = bifenthrin + acephate > amitraz : bifenthrin = buprofizen > endosulfan = imidaclorprid > acephate > acidirachtin = fosethyl-al = untreated control. Plots among the last group were mostly defoliated by SPW by the end of the six week treatment period.

Extracts from species of Solonaceae provided significant reduction in SPW adults and resulting egg and nymphal forms compared to endosulfan, M-Pede and untreated controls. Populations of adult SPW remained lower over time on treated plants compared to untreated plants. These extracts were dispersed in small quantities of acetone and mixed with water for spray application to the cotton plants.

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RESEARCH AND IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: July 1 1992 - December 31, 1992

Application methods for SPW included in these trials are discussed by H. R. Sumner et al. (these proceedings). Analytical analysis of spray deposition and residues are discussed by Womac et al. (these proceedings). Weekly applications of bifenthrin + acephate were made with each piece of equipment. Results from counts of immature stages of SPW are not yet available as the samples were made photographically and counts of the photos are still in progress. Results from adult counts on sticky cards indicate no statistically significant differences among application methods. Numerically, electrostatic application provided the best control followed by hydraulic boom with drops, Degania, hydraulic boom without drops, Berthoud and Hydrapak shielded sprayer. The relative condition of the crop in the plots followed very similar trends with the poorer treatments being defoliated by the end of the test. The shielded sprayer plots were not sprayed during the first week of the trial because the equipment was not as yet available. This late start may have had a significant influence on the results as the SPW population was undergoing rapid expansion at this time. At the end of the trial, it was determined that the electrostatic charge on the particles was about half of the level that was desired by the manufacturer. It is unclear if this had an impact on the results. Also, because several of the machines (particularly those that were air assisted) were tractor mounted on 3-point hitch attachments, we were not able to raise the booms high enough over the plant canopy to provide desired coverage of the upper portion of the plant. None of the application devices provided outstanding control as populations continued to build in the plot areas, just not as fast as untreated areas.

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RESEARCH AND IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: April 15 - November 13, 1992

Two levels of aircraft wake intensity, produced using aircraft speeds of 90 and 115 mph, were evaluated for effects on deposition of *Beauveria bassiana* sprays in cantaloupe and cotton (Monte Alto, TX) on four different canopy sizes for each crop. Total deposits on cantaloupe leaves were higher for 115 than for 90 mph when plants were small but there was no difference for mature plants. Percent area coverage and droplet density on water sensitive paper (WSP) attached to leaves were higher for the lower aircraft speed as the crop matured. Volume median diameter for spray on WSP on the tops of cantaloupe and cotton leaves (ave. 145 μm) was about twice that for spray on the bottoms of leaves (ave. 76 μm). About 2/3 of the spray volume on the bottom of cantaloupe and cotton leaves was composed of droplets smaller than 100 μm diameter. The 90 mph airspeed gave higher deposits than 115 mph on the bottom of cotton leaves at the top of the plants but did not do so at the mid-canopy height. Airspeed did not affect the percent area coverage on WSP attached to cotton leaves. There was no difference in dye deposit on the bottoms of cantaloupe leaves for spray applied with an aircraft at 90 or 115 mph compared to Berthoud air-assist or conventional-boom ground sprayers. The conventional-boom ground sprayer deposited more, and the Berthoud less, on the tops of leaves than did the other treatments.

Six aerial applications of Orthene and Capture were made in cotton and spray deposition was sampled for two different canopy sizes near Mercedes, TX (LRGV) while comparing the deposition and efficacy for a conventional aerial application spray boom at 115 mph to that for a modified spray boom equipped with Chimavir winglets at 105 mph. Total spray deposits on cotton leaves at mid-canopy height were higher for the conventional boom. The winglets deposited almost twice as much spray on the bottom of the leaves at the top of the canopy but there was no difference in deposits on the bottom of leaves at mid-canopy. Seventy-seven percent of the spray volume deposited on WSP on leaf bottoms was composed of droplets smaller than 100 μm diameter.

Comparisons of spray deposition on cotton leaves and water-sensitive cards for a conventional aerial application spray boom at 90 and 115 mph and a boom equipped with Chimavir winglets at 105 mph were conducted in small (unlapped) and large (lapped) canopy cotton near College Station, TX. In the large canopy, deposits on the bottom of the leaves were higher for the conventional boom at 90 mph and for the winglets than for the conventional boom at 115 mph. The conventional boom at 90 mph gave higher deposits on the underside of the leaves at mid-canopy height in the smaller cotton plants.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemi al Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: February 1991-October 1992

A project to characterize insecticide resistance in the sweetpotato whitefly (SPW), *Bemisia tabaci* Gennadius, in Florida was continued. Laboratory cultures of SPW were established in 1991 from samples of infestations from five commercial tomato farms. Bioassays were conducted with sticky tape impregnated with chlorpyrifos, endosulfan, and fenvalerate at concentrations representing 1X, 5X, and 1OX the LC50 of these insecticides for a strain known to be susceptible. Cultures were established in 1992 from samples taken from a heavily infested planting of cantaloupe, a watermelon planting that followed a planting of tomato, and a planting of tomato used for an insecticide evaluation. Two cultures were started from the tomato planting at the end of the season, one from endosulfan treated plots and one from bifenthrin treated plots. Susceptible and resistant laboratory strains, both originating from central Florida, were also included in the 1992 study. The 1992 bioassays were conducted with glass vials containing a dosage series of dried deposits of bifenthrin and endosulfan. Results from the 1991 study indicated reduced sensitivity to endosulfan in five populations and fenvalerate in four populations. No reduction in sensitivity to chlorpyrifos was indicated. Results from the 1992 study indicated that the strain from the heavily infested cantaloupe field was as susceptible to bifenthrin and endosulfan as the susceptible reference strain. The three remaining strains were more resistant to endosulfan and bifenthrin than the susceptible reference strain. The strain from watermelon was the least resistant. The most resistant was the strain from the bifenthrin treated tomato research plot, which was most similar to the resistant reference strain. Compared to the strain from the bifenthrin treated plots, the strain from the endosulfan treated plots was as resistant to endosulfan but not as resistant to bifenthrin. These results indicate that different resistance levels can develop in Florida SPW populations and that immediate action should be taken to implement resistance management strategies to conserve insecticide susceptibility in SPW.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: January-December, 1992

A number of conventional insecticides, insect growth regulators and biorational products were evaluated for efficacy vs *Bemisia tabaci* on poinsettias and chrysanthemums in greenhouse experiments. Pesticides were applied as granules, as well as in high and low-volume sprays.

Materials evaluated in one or more experiments with high-volume sprays or granules applied to the potting mix included imidacloprid (NTN), Margosan-0 plus pyrethrum, buprofezin WP, abamectin 0.15EC, fenoxycarb 25WP, BAS 300 11 I 75WP, and BAS 9111 20EC. Experiments were conducted in cheesecloth-covered cages or on greenhouse benches. Whitefly control was evaluated in cage experiments by hanging two 5x5 cm yellow sticky traps in each cage. Trapped adults were counted weekly and traps were replaced. Plants were also sampled periodically for whitefly nymphs. On greenhouse bench experiments, sampling was done by examining plants, or by placing vegetable oil-coated plates around the base of plants to catch adults as they fell from plants.

The imidacloprid applications, as granules or foliar applications, provided the best and longest lasting control (6 weeks+) with a single application. BAS formulations, fenoxycarb and buprofezin also provided good whitefly control. The Margosan-0 plus pyrethrum formulation did result in good adult kill, but whitefly numbers were too high to realistically assess effects on immatures. In previous experiments, however, both neembased products (Margosan-0 and Azatin) were effective if applied properly to whitefly nymphs.

ULV applications of neem-based insecticides with hand-held electrostatic or "coldfog" equipment resulted in little or no whitefly control.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: Feb. 1992- Sept. 1992

Recent cooperative studies with scientists at the USDA-ARS laboratories in Beltsville, MD have identified a sugar ester isolate from the cuticular chemical extract of *Nicotiana gossei* which is very effective in controlling the SPW under greenhouse conditions. The objective of the work was to design and build equipment which would permit the extraction of several kilograms of plant material in order to obtain sufficient amounts of *N. gossei* extract for field testing. Baskets (30-in. X 9-in. X 12-in.), made from extended steel, were designed with handles at each end. A deep liquid extraction container (36-in. X 12-in. X 24-in.), made from 16 gauge aluminum sheet, was designed to accept the baskets one at a time when they were lowered into it. Solvent (10 to 15 gal. of methylene chloride) was pumped into the extraction tank and a basket of *N. gossei* plant tops was lowered into it. The plant material must be gently agitated to encourage removal of cuticular components without fracturing the leaves which permits extraction of unwanted internal components. This was accomplished by gently moving the basket up and down or by plunging the plant material. After about 30 sec. of this procedure the basket was lifted to the top of the tank and turned on its side to drain. By turning the basket on its side, solvent trapped between the leaves was able to drain back into the tank. The sample was then placed in a secondary extraction tank and treated as above. The baskets were emptied of plant material and ready for refilling. After the extraction of 50 to 60 kg, the solvent in the primary extraction tank was drained through cheese cloth into 5 gal solvent cans. Soil and other solids in the bottom of the tank were removed. After the addition of new solvent, the tank became the secondary extractor and the process was repeated. Personnel working the extraction tanks wore protective aprons, gloves, safety glasses, and OSHA approved respirators.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: April - September 1992

The sweetpotato whitefly (*Bemisia tabaci* Gen.) has been a serious pest of cotton (*Gossypium* spp.) in the Imperial Valley of California since 1981. During the autumn of 1990 a new biotype of sweetpotato whitefly (strain B) became established on vegetable crops and overwintered in greater numbers than previous years, infesting spring vegetables in 1991. The whitefly became established in 1991 cotton plantings causing much more severe damage than in years past. Cotton plants were defoliated by strain B during late July and August, greatly reducing yields. Whitefly population again overwintered on vegetable crops in 1991 to infest the 1992 cotton crop following a population increase on spring vegetables. Several insecticides or combinations of insecticides provided sufficient control of whitefly populations to prevent premature defoliation of cotton plants producing yields three to four times greater than the control.

Treatments consisted of the following seed treatments, soil and foliar applied pesticides: 1) and untreated control, 2) NTN33893 480 FS (imidacloprid) seed treatment at 2.5 g AI/kg seed, followed by a basal soil drench of NTN33893 240 FS at 0.21 kg/ha and foliar applications of NTN33893 240 FS at 0.048 kg/ha, 4) NTN33893 240 FS foliar at 0.048 kg/ha, 5) Monitor 4+ Baythroid 2EC at 1.1+ 0.032 kg/ha, 6) Capture 2EC at 0.11 kg/ha, 7) Thiodan 3EC at 1.1 kg/ha, 8) Thiodan 3EC + Capture 2EC at 1.1 + 0.11 kg/ha, 9) AD1000 (3% Neem extract at 0.048 kg/ha, 10) Orthene 90S + Danitol 2.4EC at 0.82 + 0.22 kg/ha, 11) Thiodan 3EC + Applaud 40SC at 0.82 + 0.42 kg/ha, 12) Capture 2EC + Ovasyn 1.5 EC at 0.11 + 0.27 kg/ha, 13) Thiodan 3EC + Ovasyn 1.5 EC at 0.82 + 0.27 kg/ha, 14) Ovasyn 1.5 EC at 0.27 kg/ha, 15) Applaud 40SC at 0.42 kg/ha, 16) Ovasyn 1.5 EC + Applaud 40SC at 0.27 + 0.42 kg/ha.

The best control of sweetpotato Whitefly Strain B and the highest yields were obtained from NTN33893 foliar spray only, Ovasyn + Capture, Ovasyn + Thiodan, Monitor + Baythroid, Capture + Thiodan, Orthene + Danitol, Ovasyn and Capture.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY THE REPORT: March - November, 1992.

Sugar ester isolates from 24 species of *Nicotiana* as well as extracts from *N. gossei*, field grown and field extracted, were bioassayed at low rates for activity against early instars of the greenhouse whitefly, *T. vaporariorum*. Activity against the greenhouse whitefly is comparable or higher against similar-aged nymphs of the sweetpotato whitefly in identical bioassays.

Thirteen of the 24 *Nicotiana* species evaluated produced 70% or greater mortality. Alkaloid-free extracts from the field grown *N. gossei* were highly active in all bioassays.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: January 1992-December 1992

Investigations on the efficacy of several experimental compounds for control of sweetpotato whitefly (SPWF), Bemisia *tabaci* on spring cantaloupes and fall cauliflower were conducted in the Yuma Valley of Arizona in 1992. All studies reported herein followed the research protocol established by the SPWF Workshop at Houston, Texas, March 23, 1992. In the first trial, treatments consisted of the following foliar applied pesticides: Capture+Endosulfan, Karate+Endosulfan, Karate, Aliette, Applaud, Ovasyn, Applaud + Ovasyn and an untreated control. Multiple applications of the pyrethroid+endosulfan combinations, and Applaud, either in combination with Ovasyn or alone, initiated at mid-season maintained SPWF populations at low densities relative to the untreated control. Ovasyn applied alone did not appear to provide equivalent control as the above treatments, but did perform significantly better than the control. The pyrethroid applied alone (Karate) and Aliette did not control SPWF. Correlations among adult counts and immature SPWF densities with various sample methods suggest that the use yellow sticky traps for estimating treatment differences in efficacy trials may not be appropriate. Yield data collected at the end of the study showed that the most efficacious treatments (pyrethroid+endosulfan and applaud) harvested a significantly greater number of marketable melons. Although a significant correlation was observed between melon yields and SPWF densities, further replication is necessary before precise yield/density relationships can be determined. This study suggests that SPWF can be managed with insecticides to yield marketable spring melons in the Yuma Valley of Arizona.

In the second trial conducted on melons in the summer of 1992, treatments consisted of the following foliar applied pesticides: Capture+Endosulfan, Endosulfan, Capture and an untreated control. Similar to the chemical trial we conducted earlier in the spring, multiple applications of capture+endosulfan maintained SPWF populations at low densities relative to the untreated control. Either material applied individually did not appear to provide control comparable to the combination, but did perform significantly better than the control. Significant reductions in plant growth were observed in the heavily infested untreated control. Yield data were not collected in this study because SPWF feeding damage caused excessive plant death in the untreated plots. Finally, this study suggests that under present conditions in the Yuma Valley, SPWF populations would probably require intensive management with insecticides to yield marketable melons in cantaloupes planted after May 1.

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: January 1992-December 1992

Studies were conducted in the spring of 1992 to investigate several sampling methods for estimating adult abundance of sweetpotato whitefly (SPWF) on spring cantaloupes. Three sampling methods were examined: yellow sticky traps (ST), direct visual observations of adults on the undersides of leaves (LT), and a modified Vacuum "Hand-Vac" procedure (HV). Comparisons were made in commercial melon fields, untreated experimental plots, and small plot efficacy trials.

Generally, similar trends in adult abundance were observed with each sample method at each site. Preliminary comparison among sampling procedures indicated that efficiency in adult estimates varied by experimental site. In commercial fields, the relative variation (RV) values for the LT, HV and ST methods were less than 25 on most sampling occasions. RV values were generally lowest with ST where this value was less than 10 on many occasions. In addition, estimates of adults/sample derived from all three methods were significantly correlated with egg densities on young terminal leaves and nymph densities on crown leaves.

In the untreated experimental plots, all sample methods were less efficient due to greater variation associated with mean estimates. The HV and LT methods generally yielded means with a lower RV value than the ST, but ranged from a value of 12 to 48 depending on SPWF density and plant size. The HV and LT methods were highly correlated with immature counts on each sample occasion. Correlations between adults estimated with ST and immature counts were not consistently observed.

The efficiency of adult sample methods was extremely variable when compared in efficacy trials. The mean number of adults/sample and associated variation derived with each sample method differed with type of insecticide applied and time of sample. RV values were generally lower for ST when compared in plots treated with a pyrethroid insecticide (bifenthrin) or untreated plots, whereas LT and HV estimates were less variable when compared in plots treated with a insect growth regulator (buprofusin). In addition, variation of adult estimates differed depending whether samples were taken prior to or after an application. Mean adult numbers with LT and HV were closely correlated with egg and immature densities on each sample occasion. Estimates with ST showed that adults and immatures were not correlated.

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RESEARCH & IMPLEMENTATION AREA: Section C - Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: Summer 1992 and ongoing

Pesticides have been used as the primary control strategy against SPW and will continue to be relied upon heavily in SPW management programs. However, the development of insecticide resistance in this species has highlighted the need for an effective resistance management strategy. The goal of a resistance management program should be the judicious and informed use of insecticides in order to conserve their efficacy and prolong their usefulness. Monitoring for resistance is an essential component of a resistance management program that works by supplying information on changes in SPW population responses to insecticides during the course of a crop season. Any changes in SPW populations detected in resistance monitoring should be met with modified strategies of chemical control such as the use of mixtures, rotations or synergists.

Our resistance survey using treated vials was conducted in a number of fields in the Imperial Valley, CA in cooperation with the Agricultural Commissioner's office of Imperial County during the summer 1992. Resistance of SPW to capture and thiodan was monitored. Resistance levels to thiodan determined at LC50 ranged from 5 to 48-fold. Levels of resistance to capture were much lower, the highest level recorded at 8-fold, but for the most part lower than 5-fold. These preliminary results indicate that the use of thiodan be limited so that the level of resis- tance might decline. Although the level of resistance to capture is moderate at this time, the excessive use of capture should be curtailed to preserve its utility and delay the potential onset of higher resistance levels. In addition to these two compounds, continuous regionwide resistance monitoring should be initiated for a number of other chemicals.

1. Evaluation of insecticide rotations as a strategy for management of insecticide resistance in populations of SPW in the Imperial Valley.
2. Determine the effect of mixtures of synthetic and natural chemical to optimize the actions of available insecticides.
3. Study the genetics of insecticide resistance to facilitate future efforts to analyze resistance patterns and how best to manage resistant phenotypes.

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RESEARCH & IMPLEMENTATION AREA: Section C - Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: September - November 1991

Four common detergent powders marketed in India, Nirma®, Rin®, Surf® and Wheel®, at concentrations of 0.25, 0.5 and 1.0%, applied to single cotton leaves reduced the number of adult sweetpotato whiteflies, *Bemisia tabaci* (Gennadius), (69-91%) and nymphs (97-99%). Treatments of 0.5 and 1.0% Nirma and Surf, as well as 1.0% Wheel, applied with a foot-operated sprayer to cotton reduced the number of nymphs equal to that of a 0.05% triazophos spray. Treatments of cottonseed oil and neem oil (Neemark®) at 0.5 and 1.0% applied with a foot-operated sprayer were equal in effectiveness to a 0.55% fenpropathrin spray against both adults and nymphs. The time required for spraying and the amount of spray needed was compared using a standard wand (89 cm [35 in.] with the nozzle at a 30° angle to the wand used for both "over the top" (*Heliothis*) spraying and for spraying the undersides of the leaves and a modified wand which was shortened to 36 cm (14 in.) with a nozzle tip at a right angle to the wand. The short want was easier to use for spraying the undersides of leaves of mature cotton plants and took no more spray material and only slightly longer than "over the top" spraying. Results also confirmed that the under surfaces of the leaves must be thoroughly wet with spray materials to obtain effective whitefly control.

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RESEARCH & IMPLEMENTATION AREA: Section C - Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: March - October 1992

Four field experiments to evaluate chemical control of the sweetpotato whiterly were conducted at the Texas Agricultural Experiment Station at Weslaco, Texas in 1992. Two experiments were done in cantaloupe (spring and fall crop), one in cabbage (spring), and one in tomatoes (fall). The spring trials followed the guidelines for the Nationwide Standardized Chemical Tests protocol, but fall trials differed in that five, rather than ten, sub-samples were collected per plot per sample date. The whitefly infestation in the spring increased to moderately high levels by the end of the season while in the fall the infestation level was high from the beginning of the season. A summary of the resulting season-long average large nymph counts on 7.6 cm^2 of leaf area and adult counts on sticky traps for the spring cantaloupe trial is given in the following table.

TREATMENT	RATE (PER ACRE)	LARGE NYMPHS	STICKY TRAPS
NTN 33893 (foliar)	0.112 lb AI	0.9 a*	41 abcd
Danitol + Orthene	0.25 lb AI + 0.5 lb AI	1.1 a	39 ab
Applaud + Thiodan	0.38 lb AI + 1.O lb AI	2.1 a	30 abc
NTN 33893 (side+ foliar)	0.12 g/m + 0.044 lb AI	2.4 ab	47 bcde
NTN 33893 (side)	0.12 g/m	3.0 a	37 abcd
Thiodan + Mitac	1.O lb AI + 0.25 1b AI	3.4 ab	32 a
Mitac	0.25 lb AI	3.9 ab	50 bcde
Margosan-0	2%	3.9 ab	36 abcd
Applaud + Mitac	0.38 lb AI + 0.25 lb AI	4.2 ab	38 abcd
Thiodan	1.O lb AI	7.3 abc	29 ab
RH 0345	0.25 lb AI	8.2 abc	53 cde
Capture + Orthene	O.O8 lb AI + 0.5 lb AI	8.3 abc	43 abcd
RH 0345	0.5 lb AI	11.2 abc	60 bcde
Aliette	4 1b AI	13.9 abc	7 bcde
RH 0345	0.125 lb AI	16.5 abc	52 cde
Applaud	0.38 lb AI	17.7 abc	46 abcde
Untreated check		19.3 c	63 e

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*LSD test on log-transformed values ($P<0.05$).

In general, NTN 33893 (imidacloprid), Danitol in combination with Orthene, and Thiodan in combination with Applaud provided good whitefly control in the spring and fall trials. In the fall cantaloupe trial, a single application of imidacloprid applied in furrow at planting provided exceptionally good sweetpotato whitefly control and resulted in a significant increase in yield. Complete results of all four tests are forthcoming.

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RESEARCH & IMPLEMENTATION AREA: Section C - Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: October 1, 1991 - June 30, 1992

Five application equipment designs were evaluated for control of *Bemisia tabaci* on fresh market tomatoes in the Imperial Valley, Holtville, California, from March 12 to June 23, 1992. The equipment treatments included 1) conventional hydraulic, high pressure (400 psi), high volume (30-60 gpa/ft), 2) FMC-Degania air assist system (25 gpa), 3) Berthoud air atomization boom sprayer at 25 gpa, 4) controlled droplet applicator with fan air assist (1.8 gpa) and 5) Turbothrush fixed wing aircraft (15 gpa). Weekly applications were made with various biorational insecticides at identical rates between equipment types. Biorational materials included one or more of the following products: Insecticidal soap (M-Pede 2%), 415 Foliar Oil (Sun spray at 1%), Azadiractin (Azatin 720 at 20 gms AI), Pyrethrum (Pyrenone Crop Spray at 0.05 lbs. AI) and *Bacillus thuringensis* (Cutlass IWP at 1.5 lbs/ac) for lepidopterous larvae control. In addition to these five treatments, a hard chemicals standard was included using the conventional hydraulic equipment to apply combinations of Permethrin (Ambush 2 E at 0.2 lb AI) and Endosulfan (Thiodan 3 at 1 lb AI) for *B. tabaci* and two applications of Methomyl (Lannate L. at 0.9 lb AI) for control of lepidopterous larvae. Weekly whitefly eggs and nymphal densities were highly variable and generally not as abundant as previous years early season, but late season had increased in control plots by the last sampling on June 23, to 6 eggs/cm^2 and 7.4 nymphs/cm^2. No statistical differences occurred in ova or nymphal densities between equipment types and the untreated control over the eight sampling dates due to high variation in whitefly population densities. However, the hard chemical-conventional hydraulic treatment and the biorational-Berthoud treatment had low populations of whitefly eggs and nymphs in comparison with all other treatments. No differences occurred in fruit size, number, or total tonnage produced between treatments, but tomato ripening syndrome was highly prevalent through all experimental plots. This injury did not vary statistically between treatments, but ranged between 15 and 26.6 percent of harvested fruit among equipment types and the control treatment. Deposition data comparing leaf underside coverage between equipment designs are not presently completed by laboratory personnel.

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RESEARCH & IMPLEMENTATION AREA: Section C - Chemical Control, Biorationals and Pesticide Application Technology

DATES COVERED BY REPORT: 1991-1992

The use of imidacloprid [BAY NTN 33893 (Miles Corp.)] for control of *Bemisia tabaci* (B strain) on poinsettia was evaluated in two ways. First, the use of the product when incorporated into soiless growing media was examined. A granular formulation containing 0.5% a.i. was incorporated into growing media at 0, 3.75, 7.5, or 15 lb. formulated product per yd^3 and placed into 6-inch standard pots. Rooted poinsettia cuttings ('Annette Hegg Dark Red') were planted into all pots, which were then placed into a small greenhouse room containing a vigorous colony of *B. tabaci.* Counts of nymphs and adults on four leaves per plant were then taken for 20 weeks. Untreated plants supported more than an average of 60 nymphs per leaf during most of the test. Whitefly nymphs were absent on plants in growing media treated with 3.75 and 7.5 lb. imidacloprid per yd^3 until week 17, when an average of 1.5 and 0.8 nymphs per leaf were found for the two treatments respectively. No nymphs were found on plants treatmented with the 15 lb. rate despite large numbers of whiteflies on adjacent untreated plants.

Second, three poinsettia stock plants grown for cutting production were treated with 0.5% imidacloprid granules with either 0, 18, or 49.5 g/pot. Five weeks later, cuttings were taken from each stock plant and rooted in untreated oasis cubes under mist for 5 weeks. The rooted cuttings were then potted into standard 6-inch pots containing untreated growing media and placed into a small greenhouse room containing a vigorous colony of *B. tabaci.* Numbers of whitefly nymphs per leaf remained low for two weeks on the plants taken from the stock plants treated at the high rate, and few developed past the 2nd instar. None of the nymphs on these plants developed to the adult stage. Whitefly nymphs on the plants from the stock plants treated at the low rate were initially low, but quickly increased once placed into the colony. However, survival to the adult stage was low, relative to the untreated controls.

The eventual lack of control noted in both of these trials indicates the potential to develop a bioassay for monitoring resistance to imidacloprid in *B. tabaci.*

A study of the efficacy of two insecticides (fenoxycarb, and acephate plus fenpropathrin), delivered via three types of application equipment (a hand-held hydraulic sprayer, a hand-held electrostatic sprayer, and a stationary cold-fogger) for whitefly control on poinsettia is underway.

INVESTIGATOR'S NAME (S): R. F. Severson[1], M. G. Stephenson[2], 0. T. Chortyk[1], B. W. Maw[3], J. W. Neal, Jr.[4], and G. W. Pittarelli[4] and J. G. Buta[4] .

AFFILIATION & LOCATION: USDA-ARS-Russell Agr. Res. Ctr., Athens, GA 30613[1], USDA-ARS-Coastal Plain Experiment Station, Tifton, GA 31793[2], Biol. and Agr. Eng. Department, University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793[3], and USDA-ARS, Beltsville Agr. Ctr., Beltsville, MD 20705[4].

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: January 1992 - October 1992

Studies were conducted to isolate sufficient quantities of sweetpotato whitefly biorational insecticide present in the cuticular extract of *N. gossei* to determine its effectiveness in the field environment.

From May 27 to Aug. 11, 1992, 1003 kg of *gossei* plants were extracted with methylene chloride (see Maw et. al.) from plants grown at the Coastal Plain Experiment Station, Tifton, GA (see Stephenson et. al.). The extracts were transported to Athens, GA and the solvent was removed to yield the cuticular extract (CE). The CE was partitioned between hexane and acetonitrile and the acetonitrile fraction was reduced in volume to yield the acetonitrile solubles (AS). To remove the *Nicotiana* alkaloids, the AS was partitioned between methylene chloride and 1N tartaric acid. The solvent was removed from the methylene chloride fraction to yield the alkaloid free extract which was then chromatographed on a Sephadex LH-20 column using a chloroform-methanol gradient to yield the *N. gossei* SPW biorational (Pitterelli #26). On May 27 to July 21 an average yield of CE and AS were 0.67g\kg (range of 0.46 to 0.88g/kg) and 0.29g\kg (range of 0.10 to 0.43g/kg). Average amounts of alkaloid free extract and Pitterelli #26 on dates of May 27 to July 11 were 0.18g (range of 0.07 to 0.31g/kg) and 0.17g/kg (range 0.07 to 0.30 g/kg). The biorational was packaged according to field test requirements and sent to cooperators in GA, CA, AZ, and TX.

INVESTIGATOR'S NAME (S): R. F. Severson[1], M. G. Stephenson[2], V. A. Sisson[3], D. M. Jackson[3], 0. T. Chortyk[1] and G. A. Herzog[4].

AFFILIATION & LOCATION: USDA-ARS Russell Agr. Res. Ctr., Athens, GA 30613[1]; USDA-ARS Coastal Plain Experiment Station, Tifton, GA 31793[2]; USDA-ARS Crops Res. Lab., Oxford, NC 27695[3]; University of Georgia, Coastal Plain Experiment Station, Tifton GA 31793[4].

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: 1982 - October 1992

Studies were conducted to identify potential sweetpotato whitefly control biorational insecticides from plant extracts of *Nicotiana* species.

The methylene chloride cuticular extracts obtained from field grown *Nicotiana* spp. plants at Tifton GA and Oxford NC were partitioned between hexane and 80% methanol-water. The majority of the methanol was removed from the methanol-water soluble fraction and the residue was partitioned against chloroform. When the chloroform solubles contained only alkaloids and sugar esters (mixtures of glucose esters [GE] and/or sucrose esters (SE]), preparative C_{18}-reverse phase chromatography, employing a water-methanol gradient, was used to obtain an alkaloid free sugar ester isolate. If the chloroform solubles also contained duvane and/or labdane diterpenes, sugar esters were isolated using Sephadex LH-20 chromatography with a chloroform-methanol gradient. The isolates were hydrolyzed, the free acids were converted to butyl esters and analyzed by capillary GC. To verify the presence of glucose and/or sucrose, a portion of the hydrolyzate was taken to dryness, the residue was treated with trimethylsilation reagents and the presence of the sugars determined by GC. The sugar esters were further characterized by converting free hydroxyl groups to trimethylsilyl ethers and subjecting the mixture to GC/MS. The isolates were sent to cooperators for evaluation as biorationals against the SPW.

INVESTIGATOR'S NAME (S): V. A. Sisson and R. F. Severson

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: January 1-992 - September 1992

Plant breeding studies were conducted to improve production of potential sweetpotato whitefly (SPW) biorational insecticides isolated from *Nicotiana gossei*.

The stature and growth of *N. gossei* makes it poorly adapted for cultivation. Efforts are underway to transfer the production of the sugar esters associated with the SPW biorational materials from *N. gossei* to the cultivated *Nicotiana species, N. tabacum.* In 1975 an interspecific hybridization between *N. gossei and N. tabacum* cv Florida 17 was reported. We have used a fertile allotetraploid (GGTT) from this hybrid in crosses to the high yielding commercial flue-cured cultivars K346, NC60, and SPG117. Preliminary analysis of the fertile allotetraploid indicated that production of the biorational material was not significantly different on the dry weight basis. We will be evaluating the sesquidiploid generation (GTT) for production of the biorational sugar esters in an attempt to stabilize production in a high biomass producing line which can grow using standard tobacco practices. This would greatly increase the efficiency of production of the SPW biorational for commercial use.

INVESTIGATOR'S NAME(S): P. A. Stansly and B. M. Cawley

AFFILIATION & LOCATION: Immokalee and Gulf Cost Research and Education Center,, Bradenton, FL

RESEARCH & IMPLEMENTATION AREA: Section C: Chemicaı Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: March - June 1992

Cultural methods were standard for southwest Florida raised bed, see page irrigated crops. Plots were 3 rows wide, 26 ft long and separated at either end by a 4 ft buffer. USDA protocol and treatments (Akey, 1992) were followed except as noted. Experimental design was randomized complete block with 12 treatments and 4 replications. Tomato sets, cultivar 'Sunny', were planted 23 March. Bay NTN-33893, was only applied with planting water as a drench. Weekly foliar applications (7) began on 24 April. A 3-row plot sprayer fitted with from 4 to 6 drop nozzles per row, depending on plant height. Nozzle tips were Albuz ATR Red ceramic with an average output per nozzle of 0.61 gpm at the 200 psi operating pressure. Alkalinity was adjusted with H_2SO_4. Adults were sampled 24 h post-treatment with sticky cards and also by beating 5 randomly selected plants per subplot over a 31 x 20 cm black teflon-lined pan coated with a thin layer of 16:1 vegetable oil and dish detergent wiped clean between counts. Small nymphs and large nymphs+pupae were counted as separate categories. Plots were harvested twice, the last time on 10 June.

Adults: The **black beat pan** proved to be a superior sampling method to the sticky trap for comparing differences between small-plot means (LSD = 1.80 vs 1.09 adults per sample). Correlation between the two samples was poor ($R = 0.13$, $P < 0.01$). Mean counts over sample days ($N=4$) were significantly different from the control for all treatments. In the lowest category were Thiodan and Danitol + Monitor, which were not significantly different from Brigade, Brigade + Monitor or Aliette. **Eggs:** Numbers in the control were very high compared to the treated plots which did not differ significantly from each other. **Nymphs and Pupae:** Numbers were initially low but rose steadily through the last sample date (83 da).

Significant treatment effects were seen on small nymphs before they were on large nymphs. Analysis of small nymphs over 4 post-treatment samples showed all treatments significantly different from the control. Numbers were lowest in NTN-33983, Danitol + Monitor, and Karate + Monitor plots, although differences with other treatments were not significant except for Amitraz. Analysis of mean numbers of large nymphs + pupae over all 4 post-treatment sample dates gave 3, unambiguous groupings: highest number in the check, Aliette, Margosan and Amitraz intermediate, and the remainder of the treatments with fewest counts. **Harvest:** No significant differences.

INVESTIGATOR'S NAME(S): M. G. Stephenson[1], R. F. Severson[2], B. W. Maw[3], and G. W. Pittarelli[4]

AFFILIATION & LOCATION: USDA-ARS Coastal Plain Experiment Station, Tifton, GA 31793[1], USDA-ARS Russell Agr. Res. Ctr., Athens, GA 30613[2], Biol. and Ag. Eng. Dept., University of Georgia, Tifton, GA 31793[3], and USDA-ARS Beltsville Agr. Res. Ctr., Beltsville, MD 20705[4].

RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: January 1992 - September 1992

Nicotiana gossei transplants were grown in a conventional plant bed and we followed all recommended practices, but doubled the seeding rate to 1/3 oz (9.0 g) per 100 sq yard (92 sq meters and 200 yards were seeded to yield about 20,000 plants. The objective was to obtain a sugar ester plant extract for evaluation for sweetpotato whitefly control. Field preparation followed Extension recommended practices for tobacco and labeled rates were applied of Lorsban, Nemacur, Ridomil, Tillam and Devrinol. On April 20 one acre (.40 H) was transplanted on 44-in. (114.4-cm) rows with 20-in.(52 cm) in the row and the remaining one half acre was transplanted on May 6. The test was kept moist with irrigation as needed and five replantings (10,000 plants used) were necessary to establish a complete stand. If the test could have been transplanted in early April, survival would have been much improved. *N. gossei* is a wild tobacco species from the dry central region of Australia and it is difficult to transplant because it has little stalk development which is a major energy storage area for tobacco. Fertilization consisted of a split application of 1200 lbs (544 kg) of 6-6-18 during the first thirty days and 10 lbs (4.5 kg) N as ammonium nitrate per acre after each cut back. The first cutting was made on May 27 and was the only cutting that was not in full flower. After each cutting the field was cultivated and hoed, then fertilized and watered. Cut off caused about a 10% mortality in the remaining plants. After extracting the sweetpotato whitefly potential biorational, the plant material was spread back in the field. The fresh weight of plant material obtained at each cutting was: May 27, 270 lbs; June 10-11, 513 lbs; June 30, 97 lbs; July 6, 498 lbs; July 21, 558 lbs and August 11, 270 lbs with a total of 2206 lbs (1000.6 kg).

INVESTIGATOR'S NAME(S): Harold R. Sumner, Alvin R. Womac, Gary A. Herzog and Larry D. Chandler

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: 1992

Six sprayers were evaluated and compared in cotton and peanuts for the control of sweetpotato whitefly at Tifton, Georgia. The protocol established by Womac was used with only minor modifications. Sprayers evaluated were: Hagie over the top with two TX10 nozzles per row spaced on 18-inch centers operating at 55 psi; Hagie with drops (cotton only) with three TX10 nozzles per row operating at 55 psi; Proptec trailer mounted with rotary atomizers; four 3-point hitch-mounted and PTO-driven sprayers included: Electrostatic Spraying Systems (ESS) row crop air assist model with three nozzles per row (1 2-inch centers) operating at 35 psi (air) and 30 psi (liquid), Berthoud cannon air boom with two air sheer nozzles (blue 0.060" dia) per row operating at 15 psi, FMC Degania air boom with 3.5-Albuz aps orange nozzles per row operating at 50 psi, Hydrapak Corporation over and under shielded sprayer with four TX6 nozzles directed back and up and one over the top operating at 90 psi. A mixture of Capture 2EC (0.08 lb AI/A and Orthene 90S (0.5 lb AI/A) was applied to cotton six times at weekly intervals beginning August 18, 1992 in 20 gpa of water with all sprayers except the ESS sprayer, which applied 5 gpa of water. Peanuts were sprayed with Asana XL 0.66 at 0.05 lb AI/A in 20 and 5 gpa of water as in the cotton test, on August 19, 1992. Sprayed plot widths were 24 or 30 feet in rows spaced 3 feet apart. There was some difficulty operating the tractor-mounted sprayers in the cotton since the tractor tended to drag down and damage cotton plants under the tractor. Sprayer frames were not generally high enough to pass over the plants, and the booms on the Berthoud and ESS were not high enough in some cotton to allow for the best spray discharge into the plant canopy. Modifications, and on some sprayers redesign, are needed to provide flexibility for spray discharge down and toward the rear of the sprayer to provide a horizontal component of discharge for increased exposure time of the plant to insecticide. Dye added in the spray tank indicated streaking in the peanuts with the ESS sprayer when it was operated too close to the peanut plants. Results of deposition are reported separately in these proceedings by A. R. Womac, insect control in cotton by G. A. Herzog, and insect control in peanuts by L. D. Chandler.

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RESEARCH &IMPLEMENTATION AREA: Chemical Control, Biorationals, and Pesticide Application Technology

DATES COVERED BY REPORT: October 1, 1991 - September 30, 1992

The sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius), has become one of the most economically important insect pests in the California lower deserts. Various insecticides have been used as the main control strategy against this pest and continue to be relied upon in management programs. However, resistance to a number of pyrethroids and organophosphates has developed in whiteflies. The ability of *B. tabaci* to develop resistance to insecticides rapidly is a factor that has contributed greatly to the elevation of this insect as a primary pest of field and vegetable crops.

Development of insecticide resistance in *B. tabaci* has highlighted the need for an effective resistance management strategy. The objective of this project is to seek environmentally and ecologically safe pesticides for use in high-cash value crop production that can be incorporated into integrated pest management programs in California. The greater the number of insecticides available for rotation into a SPW management program that have different modes of action, the lesser the possibility of the selection of a resistant strain of this insect.

Several materials were tested for control of SPW on head lettuce and tomatoes in Imperial Valley, California. Treatments on lettuce consisted of the following materials: untreated control, NTN 33893 (Impidacloprid), foliage spray, Forevergreen (acrylic - co-polymer), PCC 320 (soap), Margosan-O (Azadirachtin), Capture 2EC (Bifenthrin), M-Pede (soap), Thiodan 3EC (endosulfan), Neem oil, and Jojoba oil. Treatments on tomatoes consisted of the following materials: untreated control, Capture 2EC, Capture 2EC + Monitor 4E (Methamidophos), Thiodan 3EC, NTN 33893, Ovasyn 1.5EC, Applaud (Buprofizan), Aliette 80WD6 (Fosethyl), Danitol 2.4EC (Fenpropathrin), Danitol 2.4EC + Monitor 4E, Phenoxycarb 25WP, Margosan-O, Azatin (Azadirachtin), and Jojoba oil + Comate 102 (emulsifier).

Although SPW densities dropped precipitously toward the latter part of the study on head lettuce, Capture and Thiodan provided the most consistent results. Moreover, plants within the Capture plots yielded significantly higher lettuce head weights.

Our tests on tomatoes indicates that Thiodan affected SPW populations positively when compared to the untreated control. This experiment, with the exception of Thiodan, did not indicate that any material was efficaciously superior to the SPW untreated control plots. SPW adult dispersal from areas of high infestations may have obscured the efficacy results.

INVESTIGATOR'S NAME(S): D. A. Wolfenbarger

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: June through August 15, 1992

Eight treatments (NTN 33993, Endosulfan, Fenpropathrin + Acephate, Allete, Buprofezin, Margosan-O, Bifenthrin + Acephate and Amitraz) and an untreated check were compared in a test where 14 sprays were applied at 7 day intervals, to cotton plots 40-ft long and 4 rows wide, replicated 6 times. Sprays were applied season long and yields were taken. Sweetpotato whitefly adults and third instar larvae averaged 0.4 and 0.37/leaf (third leaf below the terminal leaf), respectively, in the untreated plots after 8 sampling dates. Sprays of Fenpropathrin (0.2 lb/ac) + Acephate (0.5 lb/ac) had populations of 0.048 adults and 0.06 3rd instar larvae in samples taken at the same time. Differences between populations in treated and untreated plots were not significant. Buprofezin and Bifenthrin + Acephate were the second most effective treatments after Fenpropathrin, with yields greater than the untreated check, and were the only treatments to show increased yields. None of the treatments stimulated populations of this pest insect.

INVESTIGATOR'S NAME(S): Alvin R. Womac, Joseph E. Mulrooney and Kevin D. Howard

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RESEARCH & IMPLEMENTATION AREA: Section C: Chemical Control, Biorationals, and Pesticide Application Technology.

DATES COVERED BY REPORT: 1992

A total of 9 ground sprayers and 2 aerial spray treatments were tested for spray deposit at 2 canopy heights on both the upper and lower sides of leaves. Three (3) experiments were tested on mature cotton and 1 was conducted on peanuts. These experiments were conducted at 2 locations in the U.S. Southeast: (1) Tifton, GA area, and (2) Stoneville, MS area. The Tifton tests were conducted cooperatively with Sumner, Herzog, and chandler.

Spray applications included: (1) Degonia Air Boom, (2) Berthoud air-assisted sprayer, (3) Proptec air-assisted sprayer, (4) drop-nozzle sprayer with nozzles on hoses, (5) ESS electrostatic sprayer, (6) over-the-top hydraulic sprayer, (7) Hardi Twin air-assist, (8) Hardi Mini-Variant with spouts on metal drops, (9) drop-nozzle sprayer with nozzles on metal drops, (10) Turbo-Thrush aircraft with Chimavir winglet, (11) Turbo-Thrush aircraft without winglet. Sumner described many of these ground sprayers in his report. Deposits from, the Hardi sprayers and nozzles on metal drops are currently being analyzed for chemical with a G.C. and will be reported at a future date.

Two (2) independent methods were mainly used to determine deposit on the top and bottom of leaves: (1) Leaf washes (Carlton, USDA-ARS) of pesticide residues analyzed by gas chromatography (G.C.), and (2) water-sensitive cards analyzed with a Microscience/Imaging Technology image analyzer. The procedure provided the precision necessary to separate treatment means, generally with at least 3 Duncan's 'letters per ranking criteria.

The results indicated that the high-volume air-assisted sprayers (Degonia, Proptec, Berthoud) provided the greatest coverage based on total deposit means and mean deposit on the lowerside of leaves. Overall mean coverage of water sensitive cards ranged from 0.1 to 3.5%. Range of sprayer mean bifenthrin deposits were: (1) leaf upper side, 230-550 ng/cm^2, (2) leaf lower side, 130-460 ng/cm^2. Theoretically, bifenthrin (0.08 lb/ac) uniformly applied to the upper and lower sides of cotton leaves (w/ Leaf Area Index = 6) results in a uniform deposit of about 75 ng/cm^2.

TABLE C. Summary of Research Progress for Section C - Chemical Control, Biorationals and Pesticide Application Technology in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
C.1 Identify for registration, new chemicals and formulations that effectively control SPW.	Lab and field evaluation of chemicals with rates, combinations to identify promising materials.	X		Extensive studies under greenhouse and field conditions identified a number of conventional chemicals alone or in combination in Arizona, Georgia, California, Texas, Florida, Ohio, Maryland, New York and Mississippi that have potential for SPWF control on cotton, vegetables and ornamentals.
C.2 Identify for registration, biorational materials with new modes of action.	Initiate studies with oils, soaps, natural products, both organic and inorganic, to determine efficacy.	X		Results with plant-derived oils and petroleum based *Nicotiana* spp. plant extracts, neem seed products and several soap types suggest potential, and additional studies are warranted. These materials with different modes of action can play an important part in insecticide resistance management.
C.3 Develop application schedules and methods in relation to economic thresholds.	Determine SPW population levels under various chemical and biorational control systems.		X	Significant amounts of data have been collected on various crops, but economic threshold levels have not been defined.
C.4 Insecticide resistance studies.	Collect strains in different locations, crops, etc., and establish resistance patterns and levels.	X		Studies show SPWF populations ranging from susceptible to very resistant to several insecticide types. Results stress the need for insecticide resistance management efforts.
C.5 Genetics of insecticide resistance in SPW.	Collect strains in different locations, crops, etc., and establish resistance patterns and levels.		X	No research progress has been reported on genetics of insecticide resistance. However, collection and establishment of SPW colonies for detailed genetic analysis have been made in California, Florida and Texas.

TABLE C - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
C.6 Develop methods for application or delivery of materials to improve control.	Compare methods of application, e.g., aerial, ground, high volume air, and others for estimates of plant (especially underleaf) coverage. Determine spray deposition (μg a.i./cm^2) and coverage for different application techniques, e.g., aerial, ground, electrostatics, chemigation, air carrier sprays, etc. Relate efficacy to spray deposition and coverage.	X		Initial studies with electrostatic, high air volume and conventional sprayers from modifications in combination with variable spray volumes, rates of insecticide application and other variables suggest the potential for increased underleaf crop coverage which should improve insecticide effectiveness. Similarly, aerial application investigations involving air speed, loading and above crop height suggest improved delivery of sprays to target leaf areas.
C.7 Evaluate application methodologies for impact on natural enemies and SPW interactions.	Determine baseline information on existing natural enemies-quality and quantity.		X	No research progress reported largely because of research focus to identify materials with SPWF control potential. This has been accomplished and a logical extension in further trials will be determining their affect on natural enemies and development of insecticide selection and management.

RESEARCH SUMMARY

Section C: Chemical Control, Biorationals and Pesticide Application Technology

Compiled by:

Nick C. Toscano and John Palumbo

C.1 Identify for registration, new chemicals and formulations that effectively control SPW

Significant progress was achieved in evaluating promising materials with activity against SPW. Experiments conducted under green house and field conditions in Arizona, California, Georgia, Florida, Ohio, Maryland, Mississippi, New York and Texas identified a number of conventional chemicals alone or in combination that have potential for SPW control. The following insecticides were tested on cotton, vegetables and ornamentals for activity against the SPW: Aliette (fosethyl), Applaud (buprofizen), NTN33893 (imidacloprid), Brigade (bifenthrin), Capture (bifenthrin), Danitol (Fenopropathrin), Fenoxycarb, Karate (cyhalothrin), Mitac,Ovasyn (amitraz), Monitor (methamidophos), Orthene (acephate), Temik (aldicarb), Thiodan (endosulfan),BAS 30011, BAS 9111, RH 0345. Results indicate that most of the materials provided some control of SPW. In general, NTN 33893 (Imidacloprid) and combinations of a pyrethroid and Thiodan or Orthene appeared to be most efficacious. This was consistent among locations, and varied slightly between crops. In some cases, such as on spring melons, applications of Applaud were very effective in minimizing colonization. Similarly, in cotton the combination of Monitor and a pyrethroid provided control similar to that of combinations with Orthene or Thiodan. Research to further examine and evaluate new potential combinations of materials will continue.

The chemical trials were conducted in accordance with the protocols for ground application of chemical trials as established at the SPWF Workshops at Houston in 1992. Some experiments deviated slightly from the protocols to accommodate specific circumstances in some crops/locations. In addition, the accuracy of sticky traps for estimating adult populations and efficacy was questioned. Several reports indicated that adult estimates did not reflect true population densities in small plot trials. This was supported with comparisons with alternative sampling procedures such as pan counts, direct leaf counts and vacuum samples. These other procedures appeared to provide adult estimates which correlate egg and nymphal densities. Future trials should include one of these methods in addition to counts from sticky cards. Cooperation with workers in Section A. was suggested to design appropriate sampling protocols specifically for research purposes.

C.2 Identify for registration, biorational materials with new modes of action.

Progress was made to initiate studies with biorationals, plant derived oils, and petroleum based *Nicotiana* spp. plants extracts, neem seed products and several soap types determine efficacy on SPW. These studies were conducted primarily on vegetables. The following materials were evaluated for activity against SPW: Azatin, Margosan-0 (Azadiractin), M-Pede (fatty acid soap), Jojoba oil, pyrethrum, Natur'l oil (vegetable oil), Nicotiana (extract and sugar ester isolates), Nirma (detergent powder), Rin (detergent powder), Saf-T-Side (mineral oil), Surf (detergent powder) and Wheel (detergent powder). Results suggest that detergents, oils and neem seed products, either alone or in combination, were capable of reducing populations, but satisfactory control was often limited by rate, spray timing and frequency, and method of application. Field evaluations of Nicotiana against SPW were inconclusive, but laboratory bioassay suggest that the extracts are highly active against SPW nymphs. Biorationals with modes of action different from conventional chemicals may play an important part in insecticide resistance management.

C.3 Develop application schedules and methods in relation to economic thresholds

Population levels under various management systems have not adequately studied. Although significant amounts of data have been collected, yield and quality/ SPW density relationships have not been sufficiently quantified. Until this information is available, economic thresholds cannot be defined. A few reports indicated that this work will be initiated in 1993.

C.4 Insecticide resistance studies

Significant progress was made in collecting strains of SPW from different locations and establishing baseline data on resistance levels. Results indicate that resistance to some insecticides varies from susceptible to very resistant. Studies measuring susceptibility of adult populations to bifenthrin and endosulfan were reported from California and Florida. Glass vial bioassay using a dosage series of dried deposits of bifenthrin and endosulfan were conducted to measure mortality of SPW adults. Resistance to endosulfan by SPW was indicated from studies in both locations. In California, resistance to Bifenthrin by SPW populations has not been detected. Florida is reporting SPW resistance to Capture when compared to susceptible strains. Florida also reports reduced SPW sensitivity to Chlorpyrifos and fenvalurate. Techniques for monitoring resistance by SPW to materials with different modes of action and novel activity (ie. NTN33893 and Buprofuzin) have not been reported.

C.5 Genetics of insecticide resistance in SPW

No research progress was reported for detailed genetic analysis of resistance. However, field populations of SPW and establishment of colonies have been made which will readily facilitate the construction of isogeneic resistant and susceptible strains through back crossing and selection. Laboratories in California, Florida and Texas currently have established colonies and are prepared to begin genetic analysis.

C.6 Develop methods for application or delivery of materials to improve control

Progress to compare methods of ground and air application for estimation of underleaf coverage was significant. Initial studies with electrostatic, high-air volume and conventional hydraulic sprayers with variable spray volumes and rates of insecticide suggest underleaf crop coverage can potentially be increased. Preliminary findings suggest that high-volume, air assisted ground sprayers provided the greatest mean deposit on the undersides of leaves. Studies of aerial application with modified air speeds, wing loading and spray heights indicate that these variables may improve delivery of sprays to leaf surfaces. Considerable amounts of work is ongoing and much of the data is still under analysis.

C.7 Evaluate application methodologies for impact on natural enemies and SPW interactions

No significant research results provide data determining baseline information on the impact of chemical or biorational control on existing natural enemies complexes. As research progresses in the future, trials to determine the effect of insecticides on predator and parasites of SPW as well as secondary pests will become very important.

D. Biocontrol

Chairs: Lance S. Osborne and Lloyd Wendel

Committee Members: W. Jones, T. Bellows, A. Cohen, R. Creamer, and M. Rose

1. Abstracts
2. Table D
3. Research Summary

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORTS: August - September, 1992

Distribution of the fungus, *Beauveria bassiana*, as the product *Naturalis L* against the sweetpotato whitefly (SPW), *Bemisia tabaci*.

The SUNDANCE FARM of H. Wurtz, Coolidge, AZ was chosen for the study site. A 32-acre field was divided into 16-acre halves and each half was subdivided into 6 sampling plots. *B. bassiana* was applied to one half of the field and the synthetic pyrethroid bifenthrin to the other half as a standard for comparison. Twelve rows were retained as an untreated check and divided into 6 sampling plots. Five applications were made by ground in August and September. SPW, leafminers, and beneficial were sampled. At the end of the application regime, average whole leaf counts were 3.3, 15.4, and 18.8 large nymphs for fungus and pyrethroid treatments,and adjacent control rows, respectively (1st is significantly different from the 2nd two). The fungus and pyrethroid treated plots probably affected the numbers of SPW in the control rows. By comparison, an adjoining field of a neighboring farm, separated by only a dirt road and an irrigation ditch (about 70 feet), that had received aerial applications of insecticides (i.e., best farm practices for the area) had a mean of 80.6 SPW nymphs per leaf and this difference was highly significant. Non of the cotton, neither leaves nor lint showed signs of stickiness in our experimental plots. In contrast, both leaves and lint showed some stickiness in the adjoining field. Adult SPW in the fungus and pyrethroid treated plots (five 2-minute vacuum samples) had significantly separated means of 418 and 2300 , respectively (samples courtesy of Dr. George Butler). Additionally, leafminer populations remained about the same for both treatments. SPW adult counts from sticky cards and other data are being analyzed.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: March through October 1992

Populations of *Bemisia tabaci* (SPW) and its parasitoids were followed on three ornamental plant species in the Imperial Valley, California. Plant species monitored were hibiscus, orchid tree, and snail vine. A 20 leaf sample was collected biweekly from replicates of each species. Sampling commenced in late March and will continue through 1993.

Results: All ornamentals showed similar seasonal patterns of SPW population development. SPW entered spring at very low levels. Fourth instar nymphs averaged less than one per leaf and there was little additional reproduction. Through most of the summer reproduction on the ornamentals was limited and late instar nymphs remained below 1 per leaf through late July. By mid-October, 4th instars ranged from 20 to 55 per leaf on hibiscus and orchid tree and 3 to 7 on snail vile. The lighter density on snail vine appeared related to host acceptability rather than smaller leaf size.

Parasitization was between 30% and 70% from March through April. Too few nymphs were recovered in the samples between May and July to determine parasitization. As the whitefly population increased, parasitization gradually increased averaging around 30% in October. *Eretmocerus californicus* accounted for 94% of the parasitization throughout the year. *Encarsia luteola* (= *deserti*) and *Encarsia meritoria* was responsible for the remainder.

Late summer and fall increases of SPW on ornamentals was coincident with production on/and adult movements from crops. Massive inundation by SPW may account for low parasitization.

INVESTIGATOR'S NAME (S): George D. Butler, Jr., and T. J. Henneberry

AFFILIATION & LOCATION: Western Cotton Research Laboratory, USDA-ARS, Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: May and October 1992

Drapetis flies were observed with adult sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius), impaled on their beaks in a Tempe, AZ cotton field in 1984, a Coolidge, AZ rapini field in 1991 and under laboratory conditions at the Western Cotton Research Laboratory, Phoenix, AZ in 1991. This is not unsuspected since males of the dipterous family Empididae are known to carry food gifts in premating behavior with prospective mates.

In preliminary greenhouse tests with *Drapetis* and *Bemisia* adults in dishes with watermelon leaves, there was a 99% reduction in the number of adult *Bemisia* after 6 days and a 73% reduction in the number of *Bemisia* eggs laid. In a second test, after 3 days, the number of adult *Bemisia* was reduced by 93% and the number of eggs by 79%. Thus adult *Drapetis* may play an important role in regulating *Bemisia* populations.

Drapetis was the most abundant predator in many Arizona cotton fields during studies in 1992. In mid-June, two 50 sweep net samples were taken in each of 42 cotton fields in the Coolidge-Casa Grande area. There were 1.5 times more *Drapetis* adults than the total number of *Spanagonicus, Rhinacloa, Nabis, Geocoris,* reduviids, *Collops,* and *Hippodamia* (692 *Drapetis* and 434 other predators).

To determine the population of *Drapetis* in cotton fields, 1-min or 2-min vacuum samples were taken during June, July, and September. The numbers of flies present varied widely from field to field. For instance, in the 35 cotton fields sampled from Casa Grande to La Palma, AZ on June 25, 1992, 5 fields had more than 20 adults in 1-min samples, 12 had only 1 or 2 flies and 8 had none. The numbers of adults decreased during the season in vacuum collections from 16.1 per min. on June 22, to 6.9 on June 25, 8.0 on July 2, 4.5 on July 14, and 2.2 on Sept. 8. In contrast the number of SPW increased dramatically during the season in the same cotton fields.

The number of *Drapetis* flies sampled also differed in cotton fields in different sampling areas. On June 29, 1992, an average of 3.9 flies were caught in 2-min vacuum samples at Gila Bend and Gila Valley, AZ, 11.8 in the Yuma Valley, AZ and only 1.1 in the Somerton-San Luis, AZ area. only 3 days before, 2-min vacuum samples at Coolidge averaged 28.8 flies with 13 of 15 fields sampled with more than 12.0 flies. Two of these fields had 82 and 86 flies per 2-min vacuum sample, the latter field was adjacent to an alfalfa field. The source of the *Drapetis* flies is unknown at the present time.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: May and October 1992

The sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius), most severely infest hibiscus and lantana of the common ornamental plants in the urban areas of Arizona. To estimate the abundance of whitefly parasites, one-minute vacuum samples were made September 21-23, 1992 in the Tempe-Mesa area in several nurseries and on roadside plantings at 1-mile intervals. An average of 592 parasites/min., most probably *Eretmocerus californicus* Howard, were collected from 8 samples from hibiscus and an average of 263 parasites/min. were collected from lantana. The leaves of many of the lantana plants were dry or dead due to the serious SPW infestations so fewer nymphs were available for parasite development. One sample from cape honeysuckle had 900 parasites/min.

Eight vacuum samples were also obtained from lantana in the town of Coolidge, AZ, located within an agricultural area, on September 29, 1992 with an average collection of 308 parasites/min. One lantana sample had 1290 parasites/min. collected at the ranch home in the center of Sundance Farms. The nearness to treated cotton did not appear as important as the fact that the plants had not been treated with insecticides.

On October 1, 1992, 2-min vacuum samples were made in cotton fields in the Coolidge area. Of the 15 cotton fields sampled, parasites were collected in only one of the fields and the sample had only 4 individuals. Earlier in the summer, 2 min vacuum samples in 36 cotton fields in the Coolidge area contained only 8 parasites on July 1 and 7 parasites on July 8. No parasites were collected in 30 cotton fields in samples taken from Avondale to Waddel, AZ on July 13, 1992.

Thus it appears that parasite activity and abundance is high in urban areas or in non-sprayed rural areas. Other factors may be involved and additional research is needed to quantify differences in parasitic abundance on different SPW hosts under insecticide-treated and untreated conditions.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: October 1, 1991 - October 1, 1992

These following parameters were used to test the potential of predators to control sweetpotato whiteflies (SPW): 1) search characteristics (saltatory, ambush or cruise), 2) search area/day, 3) handling time, 4) refractory period (intersearch interval), and 5) kill rate/day. Also tested were nutritional value of SPW to each. Species tested were *Geocoris punctipes, Nabis alternatus, Hippodamia convergens, Cryptolaemus montrouzieri, Chrysoperla carnea, C. rufilabris* and *Delphastus pucillatus*. Comparative results are as follows: adult *G. punctipes* can search 15,000 cm sq./per day, and the leaf area of an early fruiting cotton plant is about 14,000 cm sq.; thus *G. punctipes* can search about 1 plant/per day. In comparison, *D. pucillatus* adults can search less than half of this area per day. Prey handling time for *G. punctipes* is about 3 minutes for 3rd instar (SPW) nymphs and about 1.25 minutes for *D. pucillatus*. Each *G. punctipes* can consume about 60 3rd instar SPW/day, and *D. pusillatus* consumes about 15. Comparisons are being used to model comparative predator potential and to provide guidelines for numbers that must be released in relationship to plant phenology and SPW population size.

A laboratory culture of *G. punctipes* that has been fed artificial diet and no insects as prey for over 100 continuous generations was used in several field cage release tests. The culture is now being up-scaled by APHIS and is being maintained at about 50,000 *G. punctipes*. The releases were in sleeve cages in citrus and surface cages in early season alfalfa and late season cotton. In the cotton study, the population size of SPW was about 8 billion eggs/acre, 8 billion nymphs/acre and about 5 billion adults. The study was made to determine survival of the laboratory culture of predators under field conditions in mid-summer. Predators were released at a rate of 375 4th and 5th instars/cage into 5 cages that were 5 row feet long, while another five cages were used as controls. An average of 28% of the released predators were recaptured per cage after 15 days. Nearly all predators had reached their adult stage by the time of recapture. Numbers of eggs and nymphs in predators-treated cages were consistently lower than in control cages, but SPW populations were too variable to allow any claim of significant reductions in SPW numbers caused by predators. The survival and development to adult stage under very severe field conditions (daily highs of 43°C and lows of 30°C) is noteworthy.

INVESTIGATOR'S NAME (S): Ray Carruthers, Steve Wraight and cooperators

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: January 1992- October 1992

An effort was initiated to evaluate and develop insect pathogens as biological control agents of the SPW. The objectives of the BPCRU project were to conduct evaluations of: 1) pathogens from the ARS Collection of Entomopathogenic Fungi, 2) pathogens collected by ARS scientists from overseas, 3) local pathogens collected by our unit and cooperators, and 4) a specific fungal product under development by J. Wright (Naturalis-L). Through these efforts. we have acquired over 60 fungal pathogens, which we have only begun to test. These materials include both *Beauveria bassiana and Paecilomyces spp.* that are known SPW pathogens. Some isolates under evaluation were collected from areas where fungal pathogens have been found causing extensive mortality. *Paecilomyces spp.* collected in countries where SPW is indigenous may hold the most potential for long term SPW control (see report by L. Lacey and A. Kirk).

At this time, we have accomplished a substantial amount of work specifically in the logistic planning of program activities, acquisition of infective germplasm, development and evaluation of precision bioassay systems, establishment of cooperative interactions with private industry (Mycotech Corp. who is mass producing test fungi) and USDA-APHIS (Phoenix, AZ and Mission, TX, who are interested in application of these materials), and in the specific evaluation of the mortality induced by some *Paecilomyces spp.* and the *B. bassiana* from Naturalis-L. We have identified several isolates of these fungi that are highly pathogenic to SPW and that can be mass cultured *in vitro* using industrial production techniques developed by Mycotech. Current and future activities will continue to focus on isolate screening under optimal bioassay conditions, although increasing emphasis will be placed on experiments to characterize the effectiveness of these fungi under suboptimal temperature, moisture and solar radiation conditions more representative of actual field conditions. Experimental activities will include pathogen related studies on the duration of the incubation period, sporulation potential from host cadavers, spore survival (both formulated materials and those produced naturally from host cadavers) and infection processes under varying environmental conditions.

In support of these efforts, a rapid staining method has been developed to assess spore viability using fluorescence microscopy and vital stains. Propidium iodide causes dead spores to fluoresce red under an excitation filter of 450-490 nm, while fluorescein diacetate causes viable spores to fluoresce green. This technique has been useful in quality control assessments of *B. bassiana* spores associated with Naturalis-L and will be used in assessing spore viability in studies where spores are exposed to differing environmental conditions in laboratory and field studies. Controlled environment studies will be conducted in the laboratory using an Oriel solar simulator with a temperature controlled exposure surface and on leaf surfaces in humidity regulated cells while closely maintaining ambient temperature.

INVESTIGATOR'S NAME (S): James R. Hagler and Steve E. Naranjo

AFFILIATION & LOCATION: USDA-ARS, Phoenix, AZ

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: January 1992 - Present

We are attempting to define and quantify the impact of naturally occurring predatory arthropods preying on sweetpotato whitefly in southwestern desert cotton. In 1992 we estimated population densities of sweetpotato whitefly eggs and approximately 25 species of predatory arthropods at three sites in Maricopa county, AZ at weekly to bi-weekly intervals. Sweetpotato whitefly populations remained at low densities at all sites up until mid-July, and then increased rapidly over the second half of the growing season. Populations of several of the most common predators were higher in the early part of the season and then declined at two Maricopa sites coincident with wide-spread aerial applications of insecticides for whitefly control. Several notable exceptions were *Chrysoperla carnea* and *Geocoris punctipes*, which were found in low numbers in the early season but increased somewhat after mid-July.

Simultaneous with whitefly and predator sampling we made mass collections of predators using a high-powered insect vacuum system (on loan from J. Ellington, NMSU) to provide specimens for performing predator gut analyses. We are currently in the process of analyzing the gut contents of these predators using a species-specific monoclonal antibody (Hagler et al. in press) that recognizes the egg and adult female stage of the sweetpotato whitefly. Using an ELISA system we have, to date, assayed nearly 20,000 individual predators representing 10 insect genera. These data are being compiled. We are also developing indices that will allow us to rate the impact of various predator species in whitefly predation. Among the more common predators that have shown positive for sweetpotato whitefly antigens are *Chrysoperla carnea*, *Geocoris* spp., *Orius tristicolor*, and *Nabis alternatus*.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: August 15, 1991 to October 12, 1992.

Data from 1991-1992 have been only partially analyzed. The following report is preliminary.

A survey for SPW and its natural enemies was conducted by PPQ officers in fields, greenhouses, and nurseries in eight southern states--AL, FL, GA, LA, MS, NC, SC, and TX. Over 700 leaf samples of more than 20 species of plants were received. SPW occurred in all eight states. Five species of *Encarsia (E. luteola, E. opulenta, E. pergandiella, E.* sp. nr. *strenua, and* E. sp. undet.) and two undetermined species of *Eretmocerus* were reared from SPW hosts. All species but one appeared to have similar geographic distributions *(E. opulenta* was collected only in southern FL).

Eighty-two of the 700 leaf samples were collected in 68 nurseries and greenhouses at scattered localities. Parasitization rates reached a low of 15% in summer and a high of 33% in winter. In fall through spring, No. emerged adult whiteflies/g dry wt. of leaf blade averaged 41% to 59% lower in leaf samples where native parasitoids were also present ($P<.05$ only in spring). Data from 67 greenhouse/nursery samples of hibiscus and mandevilla were analyzed by plotting No. adult parasitoids/g against total number of adult SPW/g. The regression equation was $y=1.91 + .12x$ ($r=.52$, $P<.01$), indicating moderate density-dependence.

MBCL received shipments of SPW natural enemies from Egypt, Greece, India, Nepal, Pakistan, and Spain. As of October 12, more than 30 collections of natural enemies were in culture. These included the following species: Coccinellidae: ?*Catana* sp., *Delphastus pusillus* complex. Aphelinidae: *Encarsia formosa, Encarsia* sp. nr. *strenua, Encarsia transvena, Encarsia* sp. A (India), *Encarsia* sp. B (Egypt), *Eretmocerus mundus, Eretmocerus* sp. A (India), and possibly other, undetermined *Eretmocerus* spp.

Encarsia formosa and Eretmocerus mundus were reared in growth chambers for releases. Numbers released: CA; *E. formosa* (75,000), *E. mundus* (94,000). TX; *E. formosa (93,000), E. mundus* (11,000). An additional 40,000 parasitoids were shipped to laboratory researchers in Arizona, Texas, and Mexico. Both species were recovered in the field for several weeks following releases at McAllen, TX, but numbers subsequently decreased, possibly because of intense competition from native *Encarsia pergandiella.*

INVESTIGATOR'S NAME (S): K. A. Hoelmer

AFFILIATION & LOCATION: USDA, ARS, Orlando

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: February 1992 to November 1992

Studies of the feeding behavior and reproductive biology of the indigenous predatory coccinellid *Delphastus pusillus* were continued (with L. S. Osborne, Univ. Florida, Apopka). In earlier lab studies, mean development time was 21 days. Longevity of adult females averaged 60 days. Larval and adult beetles will feed on all stages of whitefly, but usually fed among highest densities of eggs. Larval beetles consumed nearly 1000 eggs before pupating. Quantity of prey eaten by adult beetles depended on the stage of prey, ranging from 167 eggs to 12 early 4th instars daily. Prey consumption time ranged from 31 seconds (eggs) to 378 seconds (early 4th instars).

To compare with the lab studies, studies were also conducted in a greenhouse. Under conditions of higher temperature, humidity, and light levels than in the lab, average daily consumption of whitefly eggs by adult beetles was 252 per day, and beetle oviposition was 6 eggs per day, substantially higher than in the laboratory. In both lab and greenhouse studies, between 100 and 150 whitefly eggs per day were required to initiate and sustain oviposition. The quantity of eggs produced by *D. pusillus* was directly related to the quantity of whitefly eggs consumed above the threshold level (in press, J. Economic Entomology).

In choice tests, larval and adult *D. pusillus* were found to avoid 4th instar *B. tabaci* parasitized by the aphelinid endoparasitoids *Encarsia transvena* and *Eretmocerus californicus* in favor of unparasitized whiteflies. The degree of avoidance increased with increasing age of the parasitoid within the whitefly.

D. pusillus will also feed on eggs, immatures, and adults of several species of mites, including spider mites and broad mites. To improve mass rearing of *D. pusillus*, studies have been initiated with W. Schroeder (ARS, Orlando) to screen for acceptance and suitability of other alternate prey species and investigate artificial diets.

Preliminary studies with another coccinellid, *Nephaspis occulatus*, have shown that it has a lower functional and reproductive response than *D. pusillus*.

INVESTIGATOR'S NAME (S): Walker A. Jones

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: 1992.

Determine effects of indigenous natural enemies on regulating SPW populations. A survey of the incidence of parasitism in crop and non-crop host plants of SPW was initiated and in progress. At least four species were collected: *Eretmocerus nr. californicus, Encarsia pergandiella (= E. tabacivora), Encarsia sp. strenua* gp., and *Encarsia* sp. (uniparental). *E. californicus* dominated in cabbage during February-April. *Er. californicus* composed over 95% of the parasitism of SPW in *Lantana horrida* during early July but *En. pergandiella* became dominant by early August, eventually composing over 90% of emerging parasitoids before eliminating host populations. *En. pergandiella* was the dominant parasitoid of SPW in nurseries, greenhouses and most weedy hosts throughout the summer. A uniparental *Encarsia* sp. dominated melons in October while *Er. californicus* was most abundant during October and early November in broccoli. A more intensive analysis of SPW/natural enemy interactions in south Texas is underway in cooperation with USDA, APHIS and Texas A&M University.

Inoculate/augment parasite and predator populations through propagation and release. *En. formosa* from four different geographical regions are being compared for potential use in an augmentative approach in melon and cole crops. Development, survival, fecundity and longevity at different temperatures are being measured. Greenhouse and field trials will commence using the most promising strain.

A culture of the native predaceous mirid *Deraecoris nebulosus* was established and is being evaluated in the laboratory and greenhouse (in cooperation with USDA, ARS, Stoneville, MS).

Evaluate compatibility of pesticides with SPW natural enemies. Four parasitoid species were selected for testing for insecticide tolerance; *Eretmocerus mundus* (Spain), *Er. nr. californicus* (Texas), *En. formosa* (Greece) and *En. pergandiella* (Texas). Seven insecticides recommended for various cotton insect pests were selected. Initial testing indicated that the two pyrethroids included were most toxic to adult parasitoids 24 and 48 hours post-treatment. Further screening tests are underway.

INVESTIGATOR'S NAME (S): Lawrence Lacey and Alan Kirk

AFFILIATION & LOCATION: USDA-ARS, European Biological Control Lab, Montpellier, France

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: March 1, 1992 - present

Foreign exploration efforts by the European Biological Control Lab (EBCL, USDA, ARS) for natural enemies of the sweetpotato whitefly (SPW) were started on March 1 of this year and are still in progress. The areas in which collections were made were specifically selected to cover as broad a range of climatic and environmental conditions as possible. Some of the areas are analogous to the arid southwest of the U.S. while others are similar to the more humid gulf coast states, principally the lower Rio Grande Valley.

Initial collections were planted to coincide with overwintering and early season populations of *Bemisia tabaci*. From March 1 until June 18 collections of natural enemies, principally parasitic Hymenoptera and fungal pathogens were made in six countries (Spain, Greece, Egypt, Pakistan, India and Nepal). A second round of collections was timed to coincide with the end of the summer monsoon on the Indian subcontinent and with the characteristic buildup of *Bemisia* populations observed in the late summer. Since September 1, collections were again made in Pakistan, India and Nepal. Collections are planned during October and November for Egypt, Spain and Crete.

A total of 52 shipments have been made from the collecting areas to USDA (ARS and APHIS) quarantine facilities in the U.S. and the EBCL. Ten *Encarsia* species, *Eretmocerus mundus* and at least one other *Eretmocerus* sp. have been provisionally identified from the material thus far collected. Several isolations of *Paecilomyces* sp. and other fungi were also made.

Cooperative relations have been developed in each of the host countries that have resulted in the collection and shipment of natural enemies to EBCL and the U.S. It is envisioned that cooperative efforts will continue particularly along the lines of applied studies and student exchange.

The EBCL has recently become established in Montpellier. During the past year we have completed the outfitting of a quarantine facility that will be used for processing SPW natural enemies: established in colony a local variety of *B. tabaci* and have cultures of certain insect parasitoids.

INVESTIGATOR'S NAME (S): J. C. Legaspi, D. A. Nordlund, R. I. Carruthers

AFFILIATION & LOCATION: USDA- ARS, Weslaco, Texas

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: March - October 1992

Previous studies have shown the effectiveness of the green lacewing larvae, *C. rufilabris* against the sweetpotato whitefly (SPW), *Bemisia tabaci* in the greenhouse. However, before inundative releases of *C. rufilabris* can be implemented in the field, there is a need to obtain baseline information on the predator's life history (predation rates, development, survivorship, reproduction), and prey preference as a function of food supply and food sources. When prey were provided ad libitum, *C. rufilabris* attacked an average of approximately 350 eggs and 30 third instar SPW per predator per day. With SPW as the sole prey, the predator's development period was longer and survival rate was lower compared to development studies of *C. rufilabris* reported in the literature. Thus, we studied the development and survivorship of *C. rufilabris* provided different species and combinations of prey and food types. Natural food such as eggs of the grain moth, *Sitotroga* spp., corn earworm *Helicoverpa zea, and B. tabaci*, as well as aphid immatures, and an artificial diet were provided throughout the immature stage of *C. rufilabris*. We found that predators provided *Sitotroga* and *H. zea* eggs developed faster and increased their survival and body weight, compared to those provided an artificial diet. Predators that were provided SPW or aphid alone had a long developmental duration and died during the third instar, usually in the act of molting. However, a combination of SPW with a natural or artificial diet allowed the predator to develop to the adult stage.

To determine prey preference of *C. rufilabris*, we conducted a food choice test by providing the predator with 20 eggs of *Sitotroga spp., H. zea, B. tabaci*, and the tobacco hornworm, *Manduca sexta.* Based on predation rates, *C. rufilabris* preferred *Sitotroga* spp. followed by *H. zea, B. tabaci*, and *M. sexta*. We observed that the predator fed on *Sitotroga* and *H. zea* eggs during the first 5 minutes after providing the prey. After 24 hr, *C. rufilabris* attacked 95%, 73%, and 75% of the *Sitotroga, H. zea* and *B. tabaci* eggs, respectively. Only about 20% of *M. sexta* eggs were attacked.

To relate the life history characteristics and physiology of *C. rufilabris*, we studied their fat reserves, mainly lipids, which serve as the main source of metabolic energy. An enzymatic/ colorimetric method was used to analyze triglyceride levels of adults of *C. rufilabris* provided different diets. Preliminary analysis showed that newly-emerged adults that were provided an artificial diet had the highest total lipid content, followed by those that were provided a combination of artificial diet and SPW, *Sitotroga* eggs and SPW, *Sitotroga*, and *H. zea* eggs. Studies on a repellent effect by *C. rufilabris* on oviposition by *B. tabaci* are currently underway. Lima bean plants, *Phaseolus limnensis,* were exposed to *C. rufilabris* for varying periods from 2, 3 and 4 days. The plants were then also exposed to *B. tabaci* for 2, 3, and 4 days. We found that plants that were exposed to *C. rufilabris* and SPW for 3 and 4 days had significantly lower whitefly egg numbers compared to control plants. Currently, we are extracting a chemical from *C. rufilabris* and conducting bioassays to test the effect of the chemical extract on oviposition by SPW.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: September 1991 - December 1992

Biological control of *Bemisia tabaci* on poinsettias was attempted using two *Encarsia formosa* sources - one from whiteflies reared on poinsettias and the other from a commercial insectary, and the other from whiteflies reared on *Trialeurodes vaporariorum*. Parasitoids were released as adults onto poinsettia plants, 10% of which had been exposed to adult whiteflies to obtain an infestation. Three releases were made, each at approximately two parasitoids/plant.

Initially, the *Encarsia* from *Bemisia tabaci* parasitized a greater percentage of whiteflies, but by the end of the 11 week experiment, there was no difference between parasitism on the two groups of poinsettias. Control was acceptable with both sources, showing that *Encarsia formosa* can successfully parasitize *Bemisia tabaci*. This experiment is being repeated at the present time.

Experiments are also being conducted in the laboratory and greenhouse using the microbial material *Paecilomyces fumosoroseus* (Pfr). A spore concentration of $1x10^8$ spores/ml was more effective against a mixed age group of nymphs after a single application than $1x10^7$ or $1x10^6$ spores/mi. The spore concentrations were sprayed onto poinsettia leaves and the leaves kept in petri dishes. *Encarsia* parasitoids did not appear to be affected by any of the concentrations used. Also in petri dish experiments, poinsettia leaves containing either eggs, nymphal instars 1 and 2, 3 and 4, or "pupae" were sprayed once with suspensions containing $1x10^8$ spores/ml. After 9 days, mortality was as follows: eggs 17%, young nymphs 27%, old nymphs 84%, and pupae 87%.

In greenhouse experiments, as might be suspected, humidity was critical to the establishment of this fungus. Very little efficacy was obtained when relative humidity levels were less than 80%.

INVESTIGATOR'S NAME (S): H.J. McAuslane, F.A. Johnson, D.A. Knauft & D.L Colvin

AFFILIATION & LOCATION: University of Florida, IFAS, Gainesville, Florida

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: June 1991 to October 1992

Funding was received in 1991 and 1992 from the Florida Peanut Grower's Association to study host plant resistance to sweetpotato whitefly, *Bemisia tabaci* Gennadius (SPW), in commercial cultivars and breeding lines of peanut, *Arachis hypogaea* L (details in report by McAuslane *et al.* in Section E). We recognize the importance of selecting resistant cultivars that provide suitable habitats for parasitoids and permit high levels of parasitism so we initiated research with the following three objectives: 1) to determine which species of aphelinid parasitoids attack SPW in peanut and determine their seasonal abundance, 2) to evaluate within - plant distribution of SPW and parasitoids to help in developing adequate sampling procedures to evaluate parasitism in the field, and 3) to evaluate the effectiveness of parasitoids on several commercial cultivars and potential resistant breeding lines.

In 1991, we obtained a qualitative estimate of the SPW parasitoid complex present on peanut in north central Florida. Peanuts were sampled from August 2 until November 8 and leaflets containing SPW were placed in cardboard cans for emergence of parasitoids. Five species were detected *(Encarsia nigricephala Dozier, Encarsia pergandiella* Howard, *Eretmocerus californicus Howard, Encarsia transvena* Timberlake and two species in the *Encarsia strenua* group). *En. nigricephala* was the most abundant parasitoid and accounted for 94% of emerged parasitoids. Other species became more abundant later in the season with *En. pergandiella* making up 1% of parasitoids collected and *Er. californicus* contributing 5% of all emerged parasitoids. Individuals in the *En. strenua* group appeared in three of ten collection dates and *En. transvena* appeared in two collections.

In 1992, we evaluated within-plant distribution of parasitized and unparasitized SPW on 'Florunner' peanut and obtained estimates of parasitism on five commercial cultivars (Florunner, Southern Runner, GK 7, AT 127 and Marc I) and on 52 breeding lines from the University of Florida peanut breeding program. To evaluate within-plant distribution, lateral branches from 16 plants were collected at 10 day intervals from August 1 until November 1. Numbers of SPW red eye nymphs, parasitized and unparasitized fourth instars and other nymphal stages (first to third) were recorded from the top and bottom surfaces of each leaflet from each leaf (up to 12 leaves). Leaves of the same age (i.e. first down from the terminal, second from the terminal etc. ...) were placed together in cardboard boxes for parasitoid emergence. The data from this study are still being collected and analyzed. In conjunction with the evaluation of commercial cultivars and breeding lines for resistance (described in McAuslane *et al.* report in Section E), we assessed parasitism of SPW. Leaflets sampled for assessment of numbers of red eye nymph SPW were placed in cardboard boxes and after four weeks, emerged parasitoids and adult SPW were counted. To determine whether this method gave an adequate measure of parasitism, we also recorded young SPW nymphs (first to third), parasitized and unparasitized fourth instars and red eye nymphs from 'Florunner'. Rates of parasitism were extremely high in these noninsecticide treated plots (up to 90% of all fourth instar SPW on a leaflet) but the data have not yet been analyzed for effects of cultivars or breeding lines on rates of parasitism. This year *En. nigricephala, En. pergandiella, Er. californicus and En. transvena* appear to be equally abundant.

INVESTIGATOR'S NAME (S): O. Minkenberg, G. S. Simmons, J. van Schelt, M. F. Wilson, E. T. Natwick, and R. C. Weddle

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: December 1991 - December 1992

Development of augmentative biological control of *Bemisia tabaci* on cotton using the parasitoid *Eretmocerus californicus.*

Augmentative releases of parasitoids and/or predators within an IPM program may be an option to control SPW strain B in the Imperial Valley. Cotton was chosen as a model system, because controls of other key pests on cotton are compatible with biological control, cotton is a bridge crop between spring and fall vegetables, and cotton has a relatively long season. We chose to start releases with the aphelinid wasp *Er californicus* because records in the literature indicate it is a dominant parasitoid of SPW (strain A) in the Southwest. Our primary goal for the 1992 season was to determine whether this parasitic wasp could suppress SPW populations on cotton.

We applied three treatments: high release (ca. 50 wasps/plant), low release (ca 5 wasps/plant), and a control (no releases) in field cages (5.57 m^2 in a replicated experiment ($N = 5$), starting on May 29. Plots of cotton were located at USDA-ARS station at Brawley and UC station at Holtville. Koppert B.V. mass-reared the parasitoids in the Netherlands and the first weekly releases in the form of parasitized pupae glued on cards were initiated on June 2 and continued until July 26. Sampling of 30 leaves per cage started two weeks after the first introduction and continued at two week intervals. At the end of the season we hand picked all the lint in the cages at Brawley and weighed it.

Parasitism reached a high of 51% in the high release cages on August 5, maintained that level until the end of the season, and was significantly higher for all sampling dates, compared to both low release and control cages (ANOVA followed by Tukey HSD, $P < 0.001$). The low release treatment did not differ from the control. SPW pupal and exuviae densities were significantly lower in the high release cages than in both low release and control cages (about a three-fold difference). Again, no differences between low release and control treatments. Yield of raw cotton was in the high release, low release, control and outside the cages, 1.68, 0.78, 0.62, and 1.31 kg, respectively.

With the high parasitoid releases, we increased parasitism above natural levels, suppressed whitefly numbers, and got higher cotton yields. In the 1993 season we will examine whether similar results can be obtained when releases of *Er. californicus* are made in field plots, where both whiteflies and natural enemies can immigrate. In addition, we need to address whether the whitefly levels will be economically acceptable and biological control will be cost-effective. A combination of this parasitoid with a relatively cheap whitefly predator, such as green lacewings, may meet those conditions.

INVESTIGATOR'S NAME (S): Michael P. Parrella, Kevin M. Heinz, Judy M. Nelson, James Brazzle and Charles Pickett

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol.

DATES COVERED BY REPORT: July 1 through December 1, 1992

The feasibility of utilizing the predaceous coccinellid beetle, *D. pusillus* for *Bemisia tabaci* control was evaluated on Imperial Valley cotton from July through October, 1992. Tests were conducted in eight 1/2 acre field plots and in eight field cages (each enclose 40 plants). Approximately 50,000 beetles have been reared and released in the plots over the course of the study. While results from the field plots are inconclusive (due to mandatory termination of cotton in early September) data from the cages (which were left in place long after plants in the field were removed) were encouraging. Whitefly density in cages where beetles were released was reduced 67% compared to the densities observed in cages not receiving beetles. A similar protocol is in place on fall planted tomatoes and the studies will be repeated during the summer of 1993.

A trial initiated in August 1992 is currently in progress to evaluate the ability of *Encarsia luteola* and *D. pusillus* to control *B. tabaci* populations infesting a commercial Christmas crop of poinsettias. Parasitoids are released weekly at the rate of 0.5-1.0 per plant into three sections of the poinsettia range. No regular releases of the beetles are made; these are released only when hot-spots are detected with releases made only into these areas. Preliminary results indicate that a substantial amount of mortality through parasitoid host feeding and parasitization has been inflicted on the whitefly population. As a result, whitefly populations are well within levels deemed acceptable to the grower. The trial will be continued through harvest at which time plant quality and an economic analysis will be conducted.

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: 1991-1992

The use of the commercially-available parasitoid, *Encarsia formosa,* was evaluated for biological control of *Bemisia tabaci* on poinsettia under New York greenhouse conditions.

The relative influence of initial whitefly numbers on the *E. formosa's* effectiveness on poinsettia was assessed by releasing the parasitoid weekly at two rates (1 and 5 wasps/plant, respectively) against each of two whitefly densities (approx. 0.5 and 2 nymphs/leaf, respectively) for 1 weeks in replicated cage (1.5 x 1.2 x 0.9 m) trials. Each cage contained 8 plants. The trial lasted 17 weeks.

As expected, the higher the release rate and lower the initial whitefly density, the better the overall degree of control. However, in no case did the parasitoid releases reduce the whiteflies to a commercially acceptable level. The population trends through time indicated that multiple *E. formosa* releases appear to be able to maintain a low initial whitefly infestation at low levels. These results emphasize the importance of starting with very low whitefly levels to achieve commercial success with this parasitoid species on poinsettia. For example, in a commercial trial, weekly releases of 3 wasps per plant for 8 weeks resulted in acceptable control at sale, but the initial whitefly level was very low. The economics of such a release strategy may be prohibitive for some growers. Plans are underway to evaluate other parasitoid species for biological control of *B. tabaci* under greenhouse conditions in the Northeast.

In another study, preliminary results suggest that poinsettia leaf trichome characteristics may affect *E. formosa's* performance against *Trialeurodes vaporarium* and *B. tabaci*.

INVESTIGATOR'S NAME (S): D. J. Schuster, F. D. Bennett, G. S. Evans, J. F. Price, D. E. Dean

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: July 1989 - August 1992

The three most widely distributed and most abundant parasites reared during a survey of natural enemies of *Bemisia tabaci* on cultivated and wild host plants in Florida and the Caribbean were *Eretmocerus* sp., *Encarsia nigricephala* and *Encarsia pergandiella*. Although the data suggest that there may be a shift in seasonal abundance of some of the parasites on some host plants and possibly a seasonal displacement of one species by another, *E. pergandiella* was the most abundant parasite. Ten species of predators were observed to feed on *B. tabaci* including *Delphastus pusillus*, and another unidentified coccinellid; *Orius insidiosus*, (Anthocoridae); *Jalysus spinosus* (Berytidae); *Geocoris punctipes* (Lygaeidae); one unidentified mirid and reduviid; *Ceraeochrysa cubana*, *Chrysoperla rufilabris* and *Chrysopodes collaris* (Chrysopidae); and the spider *Theridula opulenta* (Theridiidae).

In laboratory tests, *E. pergandiella* induced mortality of *B. tabaci* by both oviposition and apparent host feeding. Nymphal mortality due to apparent host feeding ranged from about 30-35% regardless of nymphal instar provided females, while parasitization increased from about 10% for the first instar to about 45% for instars 3 and 4. Males were produced as hyperparasites of females with male emergence ranging from 0% from female nymphs 4 or 5 days old to about 95% for females 9 or 10 days old. Egg to adult development of males was 15.2 days at about 27°C compared to 14.2 days for females. Developmental times for females were similar on *B. tabaci* on tomato, squash and eggplant.

More adult *E. pergandiella* were captured on yellow sticky traps than on green, red, white, blue or black traps. However, a lower percentage of parasite adults were captured on yellow traps compared to *B. tabaci* adults.

C. rufilabris did not demonstrate a preference for the cotton aphid over *B. tabaci* nymphs when given a choice in the laboratory. When not given a choice, first instar larvae consumed more whitefly nymphs than they consumed aphids while second instar larvae consumed more aphids. Developmental time was shorter and pupae were shorter and weighed less when individuals were reared on the cotton aphid than when individuals were reared on whitefly nymphs. When larvae were given both whitefly nymphs and aphids, developmental times and sizes were intermediate.

INVESTIGATOR'S NAME (S): Alvin M. Simmons

AFFILIATION & LOCATION: *USDA-ARS, U.S. Vegetable Laboratory, Charleston, SC*

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORT: July - August 1992

A survey of parasitoids of the sweetpotato whitefly, *Bemisia tabaci*, was made in Charleston County in South Carolina. Leaves containing whitefly nymphs were collected and confined in a paper carton. The number of adult whiteflies and parasitoids which emerged were determined. Leaf samples were of snap bean grown in a screen field cage (0.2 hectare and with other vegetables growing) and from uncaged field-grown cucumber. Three parasitoids, *Eretmocerus* sp., *Encarsia nigricephala*, and *Encarsia pergandiella*, were recovered. Parasitism in the uncaged crop was ca. 1% in July and reached ca. 25% in August. Parasitism in the screen cage increased from ca. 10% to ca. 45%. Parasitism by species of some parasitoids was not determined, but *E. pergandiella* predominated in July. No insecticide was used while growing the plants. The survey will continue in 1993 and will include samples from several counties in South Carolina. Moreover, additional data will be collected on seasonal parasitism rates.

INVESTIGATOR'S NAME (S): Michael T. Smith

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RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

Identification of new natural enemies in areas of SPW origin and implement in the major agronomic regions of southern California, Texas, and Florida.

DATES COVERED BY REPORT: June 1, 1992 to Present

Preliminary investigations of imported parasitoids of the sweetpotato whitefly (SPW) were initiated. This sweetpotato whitefly:parasitoid:host plant interactions research is designed to determine the biological and behavioral performance of selected parasitoid species under different whitefly and host plant scenarios. Whitefly:parasitoid:host plant scenarios of particular interest are those where conditions are similar to those that exist in the primary agronomic systems in southern United States; the Imperial Valley in southern California, the Rio Grande Valley in Texas and in Florida.

To date, our primary efforts have been in the evaluation of several experimental protocols with the goal of developing protocols that will insure thorough parasitoid evaluation, and therefore, increase the probability of successful paring of parasitoid and plant species under particular environmental conditions. The principal parasitoid species that has been utilized in our preliminary investigations has been *Encarsia formosa*. However, our goal is to evaluate a number of different new parasitoid species from areas of SPW origin. The plant species are among the plant families of the Solanaceae, Fabaceae, Cruciferae, Malvaceae, and Cucurbitaceae, as well as hibiscus.

INVESTIGATOR'S NAME (S): [1]J.E. Wright, [2]L. F. Bouse, [2]I.W. Kirk, [2]J.B.Carlton, [2]E. Franz, [1]M. A. Latheef, and [3]R. Rektorik

AFFILIATION & LOCATION: [1]USDA, ARS, Crops Insects Research, Weslaco, TX [2]USDA, ARS, Aerial Application Research, College Station TX, [3]USDA, ARS Conservation Production Systems Research, Weslaco, TX.

RESEARCH & IMPLEMENTATION AREA: Section D: Biocontrol

DATES COVERED BY REPORTS: 1992 LRGV Cotton Season

A strain of an insect specific fungus, *Beauveria bassiana,* (Balsamo) Vuillemin FTCC 74040, formulated as *Naturalis-L*, was effective for season long control of insects in cotton, including the boll weevil, cotton fleahopper, and sweetpotato whitefly, *Bemisia tabaci*. The fungus was evaluated for full season control of insects and for early season control in combination with insecticides (bifenthrin and acephate). Aerial and ground application methods were evaluated for efficacy. Data on plant characteristics, insect damage, and lint yield were obtained for treatments and applications.

TABLE D. Summary of Research Progress for Section D - Biological Control, in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
D.1 Determine effects of indigenous natural enemies on regulating SPW populations.	Survey for and identify key natural enemies in various habitats and seasons.	X		SPWF parasitism in urban weed host habitats reached high levels, but not in limited cotton field studies. Surveys in numerous crop habitats in one or more states identified indigenous parasite activity. Drapetis spp. flies were identified as previously unreported SPWF adult predators. A monoclonal antibody for SPWF has been developed. Predaceous coccinellids and chrysopids have been identified as potential biocontrol agents. Natural enemy activity exists in most ecosystems, methods of exploitation through augmentation and conservation has potential. A tool to quantify predation has been developed.
D.2 Develop methods for enhancing habitats with refuge plantings to conserve natural enemies.	Establish refuge plantings; colonize parasitoids; sample for and identify native natural enemies.	X		Moderate to high SPWF parasitism in urban and weed host areas may be potential refuges for exploration. The possibility of exploiting this information and investigating the potential for developing refuses appears a promising approach.
D.3 Identify new natural enemies in areas of SPW origin; foreign exploration, importation and release.	Collect, identify and import exotic natural enemies from specific habitats.	X		SPWF natural enemies have been recovered from Egypt, Greece, India, Nepal, Pakistan and Spain. Mass rearing capability for parasites has progressed so some field releases have been made. Availability of exotic biological material is encouraging. Identification of material with highest potential is essential and increased effort made to evaluate new biological material introduced into crop systems.
D.4 Determine natural enemy host selection processes and mech- anisms.	Study mechanisms involved in natural enemy host foraging.	X		Preliminary studies have been initiated to evaluate exotic parasitoids under different plant habitat conditions. The successful identification, introduction and colonization of numerous biological control candidates is encouraging.

TABLE D - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
D.5 Inoculate/augment parasite and predator populations through propagation and release.	Identify best candidates for augmentation based on selected attributes.	X		*Encarsia fornosa* gave effective SPWF control in greenhouses in Ohio but not in New York. *Eretmocerus californicus* releases were promising in field cage cotton studies. These initial studies are promising and show the need for careful evaluation of parasite augmentation under a wide variety of habitats.
D.6 Determine effects of pathogens on regulating SPW populations.	Determine role in specific crops; develop culturing techniques.	X		Over 50 fungal pathogens have been collected for SPWF pathogencity screening. A staining method has been developed to identify spore viability. *Beauveria bassiana* results were promising for SPWF control on cotton. The availability of the large number of fungal pathogens with potential for SPWF control is encouraging. An effective microbial component is SPWF management could be a significant achievement.
D.7 Evaluate compatibility of pesticides with SPW natural enemies.	Laboratory screening for effect of pesticides on selected SPW natural enemies and develop baseline data.	X		Tests were initiated to select parasite species tolerant to commonly used cotton insecticides. This area of research has received minimal effort and needs to be expanded as an essential component of SPWF management.
D.8 Systematics of predators, parasites and pathogens.	Finalize taxonomist network; inventory species, literature, collections; survey NA fauna and flora; establish common curation techniques.		X	No research progress reported, *per se*; however, the estensive list of introduced exotic parasites and predators and fungal pathogens suggests that progress is being made.

RESEARCH SUMMARY

Section D -Biocontrol

Compiled by:

L. Osborne and L. Wendell

The reports submitted to us are straightforward and represent a significant portions of the ongoing research in the United States on biological control of sweetpotato whitefly. Unfortunately, these reports don't reflect on going research being conducted in many other countries and in some U.S. laboratories that did not respond.

The bulk of the research and implementation efforts during the past year fall into the following research approaches which were detailed in the Action Plan published in June 1992:

D.1 Determine effects of indigenous natural enemies on regulating SPW populations.

D.3 Identify new natural enemies in areas of SPW origin; foreign exploration, importation and release.

D.5 Inoculate/augment parasite and predator populations through propagation and release.

D-6 Determine effects of pathogens on regulating SPW populations.

D.7 Evaluate compatibility of pesticides with SPW natural enemies.

Efforts that could be identified with Approaches D2, D4, and D8 (D.2 Develop methods for enhancing habitats with refuge plantings to conserve natural enemies, D.4 Determine natural enemy host selection processes and mechanisms, D.8 Systematics of predators, parasites and pathogens) were not reflected in the submitted reports.

The lack of any reports on systematics is unfortunate because progress in this one area is critical to our ability to make significant progress in many of the other important priority areas.

Progress during the months since the Houston meeting is encouraging. We have increased our knowledge of the indigenous natural enemy complexes in most of the affected region. We have a large array of parasitoids in both state and federal quarantine facilities. These cultures are the result of efforts by numerous ARS, AES, and Aphis scientists. Laboratories throughout the region also have developed programs to both identify and evaluate various predatory insects such as: *Ceraeochrysa cubana*, *Chrysopodes collaris*, *Chrysoperla carnea*, *Chrysoperla rufilabris*, *Orius insidiosus*, *Orius tristicolor*, *Jalysus spinosus*, *Nabis alternatus*, *Drapetis flies*, *Spanagonicus sp.*, *Rinacola sp.*, *reduviids*, *Collops sp.*, *Hippodamia sp.*, *Geocoris punctipes*, *Geocoris spp.*, *Deraecoris nebulosus*, *Delphastus pusillus*, and *Nephaspis occulatus*.

Natural enemies

The increase in *B. tabaci* associated problems is accompanied by numerous new studies of its enemy fauna. These include all phases of research, from foreign exploration through taxonomy and rearing, to colonization, practical testing and studies of biology. Most noteworthy are the efforts made by American institutions (USDA and Universities) towards world-wide exploration and testing of parasitoids and other natural enemies. Some of these have already been imported into the U.S. and are reared in quarantines or being released. In addition, there is work conducted on rearing and utilizing predators and fungal organisms in the control of *B. tabaci*. Many of the studies are in their initial phases and, hopefully will be reported in

later issues of '*Bemisia*'. However, a recent contribution* permits us to present an updated version of the table presented in "Bemisia No. 5":

PARASITOIDS

NAME	STATUS REMARKS
Amitus bennetti	A1B3C3D2
Arnitus sp. from the Carribean	A3B3C3D2
Encarsia adrianae Lopez-Avila	A1B4C3D4
Encarsia brevivena Hayat	A1B3C3D4
Encarsia cibcensis Lopez-Avila	A1B4C3D4
Encarsia desantisi Viggiani	A1B?C3D4 = *bicolor* DeSantis
Encarsia formosa Gahan	A1B4C2D1
Encarsia hispida De Santis	A1B4C3D4
Encarsia inaron (Walker)	A1B4C2D4 = *partenopea* Masi
Encarsia japonica Viggiaai	A1B?C3D4
Encarsia longifasciata Subha Rao	A1B3C3D4
Encarsia lutea Masi	A1B4C2D2-3
Encarsia luteola Howard	A1B4CSD2 = *deserti* Ger. & Riv.
Encarsia mineoi Viggiani	A1B?C3D4
Encarsia mohyuddini Shafee & Rizvi	A1B?C3D4
Encarsia nigricephala Dozier	A1B2C2D4
Encarsia pergandiella Howard	A1B4C2D3 = *versicolor* Girault = *bemisia* DeSantis = *tabacivora* Viggiani
Encarsia porteri (Mercet)	A1BlC3D4
Encarsia quaintancei Howard	A1BlC3D4
Encarsia strenua (Silvestri)	A1B3C3D4
Encarsia transvena (Timberlake)	A1B4C2D2 = *sublutea* Silv.
Eretmocerus mundus Mercet	A3B4C4D3
Eretmocerus californicus Howard	A3B1C2D2
Eretmocerus sp. A *uniparental* (HI) Calif.	A3B4C?D3
Eretmocerus Sp. B *biparental* Calif.	A3B4C?D3
Eretmocerus corni Haldeman	A3B1C3D4
Eretmocerus haldemani Howard	A3B1C?D4

PREDATORS

Ceracochrysa cubana	A1B3C3D4
Chrysopodes collaris	A1B3C3D4
Chrysoperla carnea	A1B4C2D1
Chrysoperla rufilabris	A1B4C2D1
Orius insidiosus	A1B4C4D1-2
Orius tristicolor	A1B4C4D1-2
Jalysus spinosus	A1B3C3D4
Nabis alternatus	A1B3C3D4
Spanagonicus sp.	A1B3C3D4
Rinacola sp.	A1B3C3D4

E. Crop Management Systems and Host Plant Resistance

Chairs: D. D. Hardee and Gerald G. Still

Committee Members: H. Flint, D. Riley, J. Norman, D. Schuster, and J. Silvertooth

1. Abstracts
2. Table E
3. Research Summary

INVESTIGATOR'S NAME(S): Steve Castle, Tom Henneberry & Nick Toscano

AFFILIATION & LOCATION: USDA/ARS/WCRL, Brawley, CA & Phoenix, AZ, and Univ. CA, Riverside

RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: August-November 1992

The negative effects of rainfall on SPW populations have been observed in field research and/or management of SPW. For instance, immediate declines in local SPW populations have been noted in cotton and melon crops following brief, but intense rainfalls, while extended periods of above average rainfall have been implicated as a contributing factor to reduced regional populations of SPW. Research into the effects of rainfall on SPW appear warranted, especially since the potential use of sprinkler irrigations to simulate rainfall could be incorporated into management programs.

A cantaloupe field study was conducted in the Imperial Valley, CA in 1992 to examine sprinkler irrigation effects on SPW populations. Three irrigation treatments were incorporated into the factorial experimental design: 1) sprinklers applied daily, 2) sprinklers applied biweekly, and 3) conventional furrow irrigation. Four treatments replicated four times within each irrigation regimen were two fungal pathogens, the insecticide NTN, and a control. Under extreme SPW pressure, only NTN-treated plots survived more than 3 weeks after row covers were removed from the plants. However, NTN-treated plants in the furrow irrigation section began to decline soon after, with all vines collapsing when the largest fruits were only softball-sized. NTN-treated plants continued to grow in the biweekly and daily sprinkler-irrigated plots. The largest vine growth and greatest fruit production occurred in the daily sprinkler plots. The highest yield of market quality fruit came from NTN-treated vines in the daily sprinkler plots, with much lower yields from the biweekly plots and none from the furrow irrigated plots. Leaf samples (weekly) throughout the season indicated the lowest numbers of SPW eggs and nymphs were on cantaloupe leaves in the daily sprinkler plots and the highest numbers in the furrow-irrigated plots. Neither NTN nor the daily sprinkler treatment alone prevented the destruction of the cantaloupe vines by SPW. However, in combination, vines survived long enough to produce market quality fruit. These results encourage further research to better understand the mechanisms involved in reductions of SPW populations by rainfall, real or simulated. Direct effects may be a) dislodgement of SPW from the plants, or b) interruption of feeding and ovipositional behaviors. Indirect effects may be a) decrease in the suitability of the physical microenvironment or b) enhancement of the environment for fungal pathogens.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: July - October 1992

The effect of cantaloupe planting dates in combination with chemical control on sweetpotato whitefly (SPW), *Bemisia tabaci* (Gennadius) infestations and plant damage was investigated in the Imperial Valley, CA. Planting dates were 16 July, 8 August, and 27 August. None of the cantaloupe plants planted at the three dates with or without supplementary chemical control survived. Leaf samples from all treatments were taken periodically between 16 August and 6 October 1992. The seasonal average numbers of SPW eggs and late instar nymphs were 264 and 34, respectively, per square centimeter of leaf area. There were no significant differences due to planting dates or insecticide applications. The experiment was terminated on 2 October 1992. The results suggest that extremely high SPW populations in the Imperial Valley in 1992 during 16 July to 27 August exceeded levels that could be managed using existing technology. Commercial cantaloupe growers in the Valley opted to forego attempts to produce a commercial crop. The Imperial Valley Agricultural Commissioner's Office conservatively estimates the value of fall melon production in the area to be over $25 million dollars.

INVESTIGATOR'S NAME(S): Kent D. Elsey and Mark Farnham

AFFILIATION & LOCATION: USDA-ARS-SAA, Charleston, SC

RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORTS: 1992

Among groups of *Brassica oleracea*, higher number of adults and nymphs of *Bemisia tabaci* were found on brussels sprout, collard, and kale than broccoli, kohlrabi and cabbage. The number of suitable leaves available for *B. tabaci* development was a factor in this preference, eg, brussels sprout produced more leaves than other groups, while cabbage and kohlrabi produced fewer. Differences among cultivars within groups were associated with color. The red varieties, "Hubine" (brussels sprout) and "Red Acre" (cabbage) had only 10-20% the number of adults as other cultivars of their groups. In a laboratory test of 18 *brassica* cultivars, nymphal survival and development ranged from 78.5% to 96.7% and 13.0 to 14.6 days, respectively at 25°C.

INVESTIGATOR'S NAME(S): Hollis M. Flint, F. D. Wilson, Steve Naranjo

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: Summer 1992

Deltapine 50 (DP-50) and Stoneville 506 (ST-506), short season cultivars of upland cotton, *Gossypium hirsutum* L., were grown under weekly or biweekly irrigation schedules in 0.2 ha plots in a split plot design at Maricopa, AZ. The plots received identical cultural practices except for irrigation which was designed to produce plant water stress in the biweekly irrigated plots. The numbers of beneficial pest insects including the pink bollworm, *Pectinophora gossypiella* (Saunders), and the sweetpotato whitefly, *Bemisia tabaci* Genn., were determined from sweep-net and plant samples. The in-season blooming rates and agronomic properties of the cottons were determined from hand or machine picked samples. During July there was 8% more blooms in the weekly compared to biweekly irrigated plots and 11% more blooms in ST-506 than in DP-50. There were no significant differences in the average numbers of pink bollworms in bolls from the two irrigations treatments or from the two cultivars in samples collected during the season (overall average 5.5 pink bollworm/50 bolls). The seasonal average numbers of sweetpotato whitefly eggs and nymphs were significantly $\approx$ 24% greater in leaves of plants irrigated biweekly. The leaves of ST-506 had $\approx$ 26% greater numbers of eggs and nymphs than leaves of DP-50. The numbers of immature whiteflies on plant leaves caused plant mortality in late August which ended the test. Measurements of leaf water potential indicated that cotton plants irrigated on a biweekly schedule had significantly greater water stress than plants irrigated on a weekly schedule and that water stress was greatest in Aug. There were no significant differences in yield between any of the treatments, probably due to the early termination of the test. Our results indicate that the numbers of immature sweetpotato whitefly on cotton plants can be reduced by $\approx$ 47% by selecting a resistant cultivar and avoiding plant water stress.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORTS: June - October 1992

<u>Objective.</u> SPWF Host Plant Resistance in Sweetpotato.

Sweetpotato breeding lines were evaluated in greenhouse experiments for sweetpotato whitefly infestation levels. Significant differences were found among lines in the numbers of eggs and nymphs per cm^2 of leaf surface. For example, line J7/13 had 14OX the number of eggs on the first fully expanded leaf and 24X the composite number of large nymphs on leaves 1,3,5, and 8 than GA90-36. Initial observations indicate ovipositional nonpreference may be an important factor modulating susceptibility. Lines selected in the study will allow ascertaining differences in host plant chemistry responsible for susceptibility and/or resistance to sweetpotato whitefly.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORTS: September 1991 - September 1992

Populations of sweetpotato whitefly (SPWF) immatures were significantly lower on Southern Runner peanut than on Florunner peanut. The number of immatures on Southern Runner was only 19.1, 21.6, 24.0, and 42.7 percent of the number on Florunner for the August 16, 22, 29, and September 5 samples, respectively. For the August 16 samples, significant differences were noted in the number of SPWF immatures with regard to cultivar, leaf, cultivar x leaf, and leaf surface. The interaction between cultivar x leaf resulted from the lack of significant differences in the number of immatures on leaves of Southern Runner while significant differences were recorded for Florunner, with the highest number occurring on leaves 3 and 4. SPWF immatures were found on both the upper and lower leaf surfaces, but were significantly more abundant on the lower leaf surface than on the upper leaf surface.

For the August 22 samples, cultivar, leaf, cultivar x leaf, and leaf x leaf surface significantly influenced the number of SPWF immatures. Differences in the number of whitefly immatures per leaf were noted on both cultivars, but the magnitude of differences among leaves was much great for Florunner than for Southern Runner. The number of immatures on the upper versus lower leaf surface was comparable for all leaves except leaves 3 and 4, where immatures were more abundant on the upper leaf surface than on the lower leaf surface, thus producing the leaf x leaf surface interaction.

Significant differences in the number of SPWF immatures were influenced by cultivar, leaf, and cultivar x leaf for the samples collected August 29. The cultivar x leaf interaction was similar to the interaction noted in the previous sampling date in that significant differences in the number of immatures were noted among leaves for both varieties, but the differences in number of SPWF were much greater on Florunner than on Southern Runner.

On September 5, cultivar, leaf, cultivar x leaf, and leaf surface significantly affected the number of whiteflies. As in the previous two samples, significant differences in the number of immatures among leaves were noted for both varieties, but the number was greater for Florunner than for Southern Runner. Also, significantly more immatures were found on the upper leaf surface than on the lower leaf surface.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: June 1991 to October 1992

Funding to investigate host plant resistance in peanut, *Arachis hypogaea* L., to sweetpotato whitefly (SPW), *Bemisia tabaci* Gennadius, was provided by the Florida Peanut Grower's Association in 1991 and 1992. In 1991, we screened 150 commercial cultivars and breeding lines from the University of Florida peanut breeding program. Single row plots measuring 6.1 m in length were planted in late June in a randomized complete block design with two replicates. A test of five common commercial cultivars (Florunner, Southern Runner, AT 127, Marc I and GK 7) was conducted at the same time, using two-row plots replicated four times in a randomized complete block design. Lines and cultivars were sampled at ten day intervals from July 23 until November 8 by taking ten leaflets per plot (leaflets from the third leaf below the terminal leaf). Whitefly red eyed nymphs (REN) located in a 1-cm diameter area on the bottom surface of the leaflet were counted using a dissecting microscope in the laboratory.

SPW populations were low in 1991 and little useful data were obtained from the breeding lines. Trends were evident on the commercial cultivar test but only AT 127 (most REN) and Florunner (fewest REN) were significantly different (LSD, $\alpha = 0.05$). We chose for further evaluation 52 breeding lines that had few SPW and high rates of parasitism (details in report in Section D).

In 1992, we planted 52 breeding lines in single row plots with four replicates. We again performed a cultivar test which consisted of the five cultivars tested in 1991, set up in four-row plots with four replicates. Whitefly were sampled as in 1991, except that this year all REN on the bottom surface of leaflets were counted. The data have not yet been analyzed completely, but SPW populations were larger this year and several lines appear to have significantly fewer SPW than other lines. Three breeding lines had fewer REN than Southern Runner and an additional three lines had fewer than the next two best cultivars (Marc I and GK 7). This year Florunner (most REN) and Southern Runner (fewest REN) were significantly different, but the other three cultivars were not (LSD, $\alpha = 0.05$).

During these studies and other research described in Section D, we have evaluated within-plant and within-field distribution of SPW and its parasitoids. These data are expected to help us in evaluating levels of parasitism and effectiveness of natural enemies in the field.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: October, 1991 through October, 1992

Melon (*Cucumis melo* L.) was evaluated for sweetpotato whitefly resistance in naturally infested field plots. In 1991, 151 *agrestis* type plant introductions (PI) were evaluated, and 162 *agrestis* type PI, varieties and a genetic population were evaluated in 1992.

In 1991, plots were planted on 23 August, and were 8.4 m in length on 2 m centers and consisted of 10 single-plant hills spaced 76 cm apart. In 1992, plots were planted on 3 August, and were 4.2 m in length on 2 m centers and consisted of five 2- plant hills spaced 76 cm apart. Evaluations were done on a plot basis at 61 (1991), and at 28 and 56 (1992) days post-planting. Plant size was evaluated on a 1 (very small, only a few true leaves) to 9 (completely covering the bed) scale. Plant condition was evaluated using a 1 (dead [1991] or nearly dead [1992] to 9 (vigorous, flowers) scale.

In both years, the plants were heavily infested with SPW, plants were stunted. In 1991, ELISA samples were negative for lettuce infectious yellows virus. Few flowers were seen (staminate or pistillate) and virtually no fruit were produced.

There were significant differences among the entries for SPW resistance in 1991 at 61 days post-planting. None of the 151 entries in 1991 had a high, uniform level of resistance, but 20 entries had one or more plants that exhibited an apparently high level of resistance (see Cucurbit Genetics Cooperative Report 15:59-61, 1991 for more details). One plant of PI 164825 was approximately 3-4 times larger than its siblings; this plant was used as a male parent in crosses with two breeding lines.

The 1992 test was apparently more severe than the 1991 test, many plots were completely dead. Analysis of these data are incomplete at this date. PI 164825 did not, however, have any plants as resistant as observed in 1991 and the F_1 PI 164825 x 15 and F_1 PI 164825 x WMR 29 were not particularly notable. Families (F_1 BC,) from crosses of Snake Melon x Freeman Cucumber appeared to be the most resistant in 1992. These families were not included in the 1991 study.

In summary, there does appear to be variability in melon for resistance to SPW. These field tests revealed some plant introductions for further evaluation and crossing, and controlled laboratory or greenhouse tests on their interactions with SPW.

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RESEARCH & IMPLEMENTATION AREA Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: July 1, 1992 to October 31, 1992

Thirty-six soybean varieties and breeding lines from maturity groups VII and VIII were evaluated in a replicated field trial for whitefly preference/nonpreference and damage. Each entry was rated for whitefly damage (from 0 to 10, with 0 indicating no SPWF or sooty mold present and 10 indicating 100% of the upper leaves covered with SPWF and sooty mold) on 20 September and 1 October 1992. Overall mean damage scores ranged from 1.0 to 7.3. Also, in mid October each entry was monitored for whitefly activity based on a sticky trap catch after a 24h exposure in the middle of each plot. Preliminary counts indicate catches ranging from 150 to over 500 per trap. In early October, three upper trifoliates were randomly selected from each plot and the whitefly population density was determined. Mean densities ranged from 1.5 to over 104 per cm^2. On 1 October, 8 soybean types with different levels of resistance to SPWF damage were sampled for cuticular and internal chemistries. The analytical samples were obtained by dipping five leaves, 1 per plant, in methylene chloride to extract cuticular components or by placing in methanol for internal chemical extracts. Kilogram amounts of leaves from resistant and susceptible lines were sampled for isolation, characterization, and bioassay studies.

INVESTIGATOR'S NAME(S): E. T. Natwick and T. F. Leigh

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: April - September 1992

Seven cotton cultivars (Pima S6, Gumbo 500, DPL 20, DPL 50, DPL 90, Siokra and Kimbred 1135) were established at the University of California Desert Research and Extension Center near Holtville, CA, April 23, 1992. Main stem cotton leaves were extracted from the sixth node from the terminus on five dates during June, July and August. Ten leaves from each of four replicates on June 1 and June 11, and six leaves on July 13, August 3 and August 17 were examined for sweetpotato whitefly eggs and redeyed nymphs. A 6 cm^2 area on each leaf was examined for the first sampled and a 4 cm^2 area was examined for subsequent counts of immature stages.

Pima S6 and Kimbred 1135 had the greatest number of redeyed nymphs and eggs per cm^2 reaching 20.1 and 15.0, respectively, by August 3 with 280 and 228 eggs per cm^2, respectively, August 17. DPL 50 had the fewest redeyed nymphs in June and July, ranging from 0.14 to 1.6 per cm^2, but increased to 10.0 by August 3, Siokra supported the fewest redeyed nymphs overall, ranging from 0.5 to 1.7 per cm^2 in June and July, but increased to 6.5 by August 3. Siokra has an okra-leaf shape as does Gumbo 500. Okra-leaf shape is reported in the literature to be a factor in whitefly resistance. Gumbo 500 supported few redeyed nymphs (0.31 to 2.2) from June 1 through July 13, but increased to 8.7 by August 3. DPL 20 and DPL 90 were similar to DPL 50 and Siokra in June and July, but increased to 6.9 and 6.8 redeyed nymphs per cm^2 by August 3, slightly greater than Siokra.

Pima S6 leaves did not drop from the plants but were killed by whitefly nymphs by the end of August. Kimbred 1135 and Gumbo 500 were nearly defoliated by whitefly feeding by August 17. DPL 90 displayed more leaf necrosis and defoliation than Siokra, DPL 20 or DPL 50, which retained most leaves through August 17. Leaf to leaf and replicate to replicate variability was very high, but there appeared to be real differences among some cultivars.

INVESTIGATOR'S NAME(S): E. T. Natwick and F. Robinson

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RESEARCH & IMPLEMENTATION AREA: Host Plant Resistance

DATES COVERED BY REPORT: September, 1991-September, 1992

ALFALFA CULTIVAR SUSCEPTIBILITY TO SWEETPOTATO WHITEFLY, STRAIN-B

Seven alfalfa cultivars were evaluated for their relative susceptibility to colonization by the sweetpotato whitefly (SPWF) strain-B on October 23, 1991. The alfalfa cultivars included: Cibola, CUF 101, Dofari, Mesilla, Moapa 69, UC 150 and Wilson.

Alfalfa plots of each cultivar were replicated nine times in a randomized block design. Five alfalfa stems were extracted at random from each plot. The sample unit for SPWF life stages was the seventh main stem node leaf from the base of the extracted stems. The center leaflets from the trifoliate leaves were examined using binocular microscopes to count eggs, crawlers (first instar nymphs), nymphs (second through early fourth instar nymphs), redeye nymphs (late fourth instar nymphs) and empty nymphal cases (nymphal exudate remaining after adult emergence). The SPWF sample stages, mentioned above, were totaled for each five leaflet samples in each plot and data sets were analyzed.

<u>Conclusion</u>: When all the means for the samples of eggs, crawlers, nymphs, total nymphs, redeye nymphs and empty nymphal cases are compared, the cultivars Mesilla and Wilson may be ranked the least susceptible to SPWF and CUF 101 is the most susceptible to SPWF colonization . Dofari and UC 150 are also susceptible to heavy colonization by SPWF, while Cibola and Moapa 69 are intermediate in their susceptibility to SPWF among cultivars com pared in this research.

(Research supported by the Metropolitan Water District of Southern California, the Water Resources Center University of California and Imperial Valley Conservation Research Center Committee).

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RESEARCH & IMPLEMENTATION AREA: Host Plant Resistance

DATES COVERED BY REPORT: September 1991 - September 1992

Insecticides may be a useful tool for sweetpotato whitefly (SPW) strain-B control in the future, but currently are not adequate for crop protection in light of the extremely high population pressure. In order to reduce the whitefly populations to levels where biological control agents or insecticides will be effective, growers will need to adopt new cropping practices. One practice alfalfa growers can easily adopt is summer dormancy, via irrigation termination. This may not be feasible for all alfalfa stands. The duration and time of irrigation termination needed to maximize the impact on SPW without hurting the stand need further investigation.

Dr. Frank Robinson, is currently conducting alfalfa irrigation studies. Several varieties of alfalfa were grouped in four irrigation schemes of optimum, which received normal irrigation, minimal received one less irrigation than optimal in July, August and September, short stress no water in August and September, and long stress, no water July through September.

On September 20, 1992, ten stems of CUF101 were randomly sampled from each treatment and replicate. Sweetpotato whitefly nymphs were counted on the third trifoliate main stem leaf from the base of each stem. Nymphal samples included: Nymphs (crawlers through early 4th instars), redeyed nymphs (4th instars showing redeye spots of developing adult), parasitized nymphs (empty nymphal cases with a round exit hole of an adult wasp) and empty nymphal cases (y-shaped exit hole of an adult whitefly.)

In each data set, the whitefly means for optimum and minimal treatments were the largest and were not significantly different from each other, but were significantly different from the long and short treatment whitefly means $p \leq 0.05$. The long and short stress treatments had whitefly means which were the smallest and were not significantly different from each other. Therefore, irrigation management in alfalfa for a short or long stress (dormancy) period during the summer could greatly reduce SPW populations. The stress period from irrigation termination may need to be reduced to a one month duration in lighter soils to prevent stand loss.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: August - November 1991

A survey of cotton, *Gossypium* spp., cultivars and hybrids varying in sweetpotato whitefly (SPW), *Bemisia tabaci* Gennadius), susceptibility was conducted to identify potential morphological leaf characters that may be related to SPW host susceptibility. A negative correlation was shown between the number of SPW adults and increased distance from epidermal leaf tissue layers to phloem tissue, and a positive correlation was shown between adults and decreased thickness of mesophyll tissue layers. The data provide a preliminary basis for increased plant breeding investigations to incorporate these characters into acceptable agronomic type cottons as a component of SPW management systems.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: March 1992 - June 1992

The sweetpotato whitefly (SPWF) caused considerable damage to cucurbit crops in 1991 and it appeared that melons were among the more susceptible vegetables to SPWF damage in Texas. The first level in host plant resistance research is to determine the variability (susceptibility or resistance) among plant species, varieties, or hybrids. Once this level research is done it can be followed by determining the mechanisms of resistance [antibiosis (= adverse effects by plant on arthropod's biology), antixenosis (= avoidance of plant), or plant tolerance (= ability of plant to withstand infestation)] and developing resistant varieties. Studies were initiated in 1992 to determine the relative susceptibility or resistance of melon cultivars to SPWF attack at the Texas Agricultural Experiment Station at Weslaco. Selected melon cultivars were planted in 80" beds in treated and untreated field plots for the control of SPWF. Treatments were arranged in a split plot design with insecticide treatment as the whole plot and varieties as the subplot. SPWF adults were sampled weekly on whole leaves at the 3rd node from the growing point and immature SPWF were sampled on two leaf disks per leaf (total 7.6 cm^2 of leaf area) sampled at the 6th node from the growing point. Sample size was five leaves per plot for adult counts and ten leaves per plot for nymphal counts. Whitefly ovipositional preference and plant tolerance were evaluated by monitoring SPWF numbers and plant yield response. Plant damage ratings including sooty mold, reduction of plant vigor, and the occurrence of other plant diseases. Yield was evaluated in terms of total harvested weight, number of boxes, and average size class. Harvested melons were separated by size class for weight and volume determinations and yield weight is reported by size class and as totals. Differences were noted between melon cultivars in terms of yield and SPWF adults and nymphs throughout the sampling period. Explorer was associated with relatively low SPWF numbers and provided the greatest harvested weight and the highest sugar content, but had one of the smaller average size classes. Generally, greater yields were associated with lower SPWF numbers. Other cultivars that resulted in less than 20 immature SPWF per 7.6 cm^2 of leaf area in untreated plots on June 10 included Otero, Caravelle, Cruiser, Primo, and Hymark. Mainpak appeared to be the most severely affected by whitefly since it was associated with high SPWF numbers and provided the second lowest weight, the smallest size class, and the lowest percent sugar. However it should also be noted that Explorer, Cruiser, and Caravelle also responded the greatest to SPWF control; that is, all three cultivars produced significantly greater numbers of #15 melons where whiteflies were controlled. It was expected that earlier maturing varieties, such as Cruiser and Caravelle, would experience more whitefly pressure early in the season than late maturing varieties, such as Hymark and Mainpak, but this was not the case. There was no clear division of whitefly susceptibility based on duration of melon maturation. However, since the cultivars preferred by SPWF adults were different in the earlier samples compared to the later samples, it is suspected that plant age does affect the attractiveness of the melon plant to SPWF. Also since the ranking of cultivars by level of SPWF nymphs was different between the earliest and latest date, host suitability may also be affected by plant age. Generally those cultivars with low whitefly numbers late in the season produced the higher yields, so it is expected that late season infestations may affect melon production more than early season infestations. A single sample taken at a commercial farm in Hidalgo County on May 22, 1992 demonstrated that significant differences in SPWF numbers could be detected between cultivars under commercial production practices. It is interesting to note that the whitefly infestation at the time of harvest, as indicated by pupal case counts, was low on Primo and Hymark, similar to the experimental results in Weslaco. The low numbers on Gold Mark at the commercial farm was probably more related to the dried condition of the vine rather than any direct plant effects.

INVESTIGATOR'S NAME: D. J. Schuster, J. W. Scott, J. H. M. Barten, J. E. Polston

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: September 1990 - August 1992

Forty *Lycopersicon pennellii* accessions were screened for resistance to *Bemisia tabaci* under natural infestation. The most promising accessions were further tested in the greenhouse for adult survival and oviposition and for survival of nymphs in a no choice experiment. LA 1340 was nearly immune to *B. tabaci* and had the highest density of type IV trichomes. Sixteen F_3 populations from crosses of *L. esculentum* X LA 1340 were evaluated for type IV trichome exudate production using a sugar-dip method and for whitefly incidence under field conditions. Preliminary data indicate an inverse relationship of preference, for whitefly feeding and oviposition with stickiness (R^2 = 0.98). Whereas, a stickiness level of 50 mg sugar/cm^2 was sufficient to completely deter *B. tabaci* from feeding and ovipositing in a no choice situation, a level of 15 mg/cm^2 resulted in heavy infestations. The level of sticky exudate appeared to be influenced by both the density of type IV trichomes and the amount of exudate production per trichome.

Of numerous accessions of *Lycopersicon* screened under natural field inoculation for resistance to tomato mottle virus (TMoV), a geminivirus vectored by *B. tabaci* in Florida, best resistance occurred in accessions of *L. chilense*. Fifteen F_1's involving 8 *L. chilense* accessions were obtained, 10 from seed and 5 through embryo rescue. F_1's from 7 accessions failed to set fruit in the greenhouse and were backcrossed to *L. esculentum*. This BC_1 generation was grown from seed but germination was only about 2.7% so that only 43 plants were obtained with at least 2 per accession. A large scale embryo rescue effort was undertaken and 548 BC_1 plants were obtained with at least 56 plants per accession. All BC_1 plants were inoculated with TMoV viruliferous *B. tabaci* in an enclosed greenhouse and planted in the field. Three weeks after planting, 37 plants were without TMoV symptoms with at least 2 per *L. chilense* accession. No conclusions on quality or inheritance of resistance to TMoV could be made with these accessions. For LA 1960, many F_2 and BC_1 plants were obtained and a preliminary genetic analysis indicated recessive inheritance probably based on either 2 or 3 genes. However, none of the 88 F_2 plants from *L. esculentum* X LA 1960 had resistance comparable to LA 1960. Furthermore, TMoV symptoms in this F_2 seemed more severe in determinate than in indeterminate genotypes.

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RESEARCH & IMPLEMENTATION AREA: Section E: Crop Management Systems and Host Plant Resistance

DATES COVERED BY REPORT: January 1 - December 31, 1992

A host plant resistance breeding program was initiated for resistance to Bemisia tabaci, the sweetpotato whitefly, in upland cotton, *Gossypium hirsutum*. Leaf surface p and leaf trichome density were evaluated for fourteen genotypes under growth chamber and greenhouse conditions in 1992. Field trials of these genotypes (with additions) to determine field infestation and yield potential were conducted at Weslaco, Texas. SPW populations were evaluated on five different dates during the growing season. Statistical evaluation is not complete at this time. Surface and internal leaf pH and trichome numbers on these genotypes will be determined on greenhouse grown plants during the winter 1992/93. Results to date indicate that leaf surface pH is not a resistance mechanism, but results tend to verify that smoother leaves impart a degree of resistance, at least in most genetic backgrounds studied. Future research includes continued field evaluation of these genotypes for resistance, and evaluation of resistant candidates in the greenhouse under choice and no-choice situations.

TABLE E. Summary of Research Progress for Section E - Crop Management Systems and Host Plant Resistance, in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	Progress Achieved No	Significance
E.1 Determine effect of traditional crop production inputs on SPW population development.	Investigate effects of irrigation, fertilization, and plant growth characteristics on SPW population dynamics.	X		Frequent cotton irrigations reduced SPWF numbers verifying observations that water stress facilitates population development. Water management systems in crop production may be an important SPWF management tool.
E.2 Determine temporal and spatial effects of host plants on SPW populations and dispersion.	Determine SPW reproduction, population development and factors affecting them on selected major crops and weeds.	X		Considerable progress has been made in identifying SPWF population differences within and between major cultivated crops that are apparently due to some mechanism of resistance. These initial observations are resulting in selection, crossing and genetic analysis to incorporate resistance characters into acceptable agronomic types. These findings suggest the potential for identifying resistant SPWF plant germplasm.
E.3 Determine effect of colored mulches, trap crops, intercropping, row covers, and other innovative cultural practices as potential SPW control methods.	Identify cultural practices in crop production systems affecting SPW biology and behavior.	X		Overhead sprinkler irrigation reduced SPWF numbers in cantaloupe plantings. Populations were too high in Imperial Valley to exploit cantaloupe planting dates between 16 July and 27 August. The mode of action (disturbance, physical, mortality, etc.) for sprinkler irrigation needs to be determined and exploited as a potential SPWF suppression method.
E.4 Develop reproducible evaluation techniques to isolate resistant germplasm.	Determine rapid, reproducible evaluation techniques for identifying resistance germplasms.	X		Experimental and mesophyll leaf tissue morphological differences appear to be associated with SPWF numbers on different cotton lines. Trichome exudate production in tomatoes was inversely related to SPWF feeding and oviposition. Cotton trichome density was related to high SPWF densities on cottons. These identified characteristics as related to SPWF numbers provide preliminary guidelines to modifying plants to reduce SPWF.
E.5 Identify resistant germplasm to SPW and associated viruses and plant disorders.	Collect potential sources of resistance germplasm.	X		SPWF population differences among *Brassica oleracea* groups suggest plant size and color affected preference. Oviposition preference appears to be a factor in sweetpotato breeding line evaluations. Significant differences also occurred between peanut cultivars, melons, soybeans, cotton and tomatoes. Identified resistant characters in *Brassica* provide opportunities for further selection and breeding for SPWF resistance.
E.6 Conduct plant breeding studies to select SPW resistant plant germplasm.	Conduct plant breeding studies to incorporate resistance into acceptable plant types.	X		Tomato plant selection and crossing for tomato mottle resistance has identified several sources of useful germplasm. Selection and breeding for virus-resistant tomatoes has potential.

Section E: Crop Management Systems and Host Plant Resistance

Compiled by
D. D. Hardee and G. G. Still

E.1 Determine effect of traditional crop production inputs on SPW population development;

E.2 Determine temporal and spatial effects of host plants on SPW populations and dispersion; and

E.3 Determine effect of colored mulches, trap crops, intercropping, row covers, and other innovative cultural practices as SPW control methods.

Immediate declines in local SPW populations observed after brief but intense rainfall. Results from sprinkler irrigation not as noticeable. Direct effects from rainfall include dislodging from plant and interruption of feeding and oviposition. Indirect effects result from a decrease in suitability of the physical microenvironment and enhancement of a suitable environment for fungal pathogens.

Cantaloupes planted on 16 July, 8 August, and 27 August were unable to survive attacks of SPW with or without chemical control.

Texas A&M University has initiated programs to (1) determine how irrigation reduces SPW numbers with a rainfall simulator and a sensing system to quantify irrigation factors, (2) identify cooperators and sites for field tests, and (3) evaluate soaps and other non-chemical substances usable in irrigation systems.

Number of SPW less in cotton with weekly irrigations than in bi-weekly irrigations, suggesting that water stress in cotton facilitates infestations. Numbers of SPW eggs and nymphs lower on Delta Pine 50 than Stoneville 506.

E.4 Develop reproducible evaluation techniques to isolate resistant germplasm;

E.5 Identify resistant germplasm to SPW and associated viruses and plant disorders; and

E.6 Conduct plant breeding studies to select SPW resistant plant germplasm.

Some varieties and cultivars of squash show tolerance to SPW as expressed in little or no leaf silvering.

Tests with cotton having multi-adversity resistance (MAR) germplasm revealed that (1) glabrous cottons were less affected by SPW than hairy cottons, (2) SPW was less attracted to strains with red plant color, and (3) three advanced MAR-6 strains were less attractive and less sensitive to SPW, and had very little sticky cotton. Brussels sprouts, collard, and kale had more SPW than broccoli, kohlrabi, and cabbage. This decrease was attributed to the presence of fewer leaves on the latter crops. Also, red varieties of cabbage had 10-20% as many SPW as other cultivars.

Significant differences were found among lines of sweetpotatoes in the numbers of eggs and nymphs of SPW per cm^2 of leaf surface. Apparently ovipositional non-preference is the regulating factor.

Numbers of SPW immatures were significantly lower in Georgia on Southern Runner peanut than on Florunner peanut. Significantly more immatures were found on the upper leaf surface than on the lower leaf surface. Several lines of peanuts appear to have significantly fewer SPW in Florida than other lines.

There appears to be variability in melons for resistance to SPW. Some plant introductions are promising enough to justify further evaluation and crossing.

Thirty-six soybean varieties and breeding lines from maturity groups VII and VIII showed considerable variation in numbers of SPW and presence of sooty mold, indicating some degree of resistance.

Differences were noted among cotton cultivars as to number of SPW numbers, leaf necrosis, and defoliation. Okra-leaf cottons seemed to affect numbers; Pima cotton had largest numbers of SPW. Numbers of SPW on several varieties of cotton were not influenced by leaf surface pH, but research verifies that smoother leaves impart a degree of resistance in most genetic backgrounds studied.

Two cultivars of alfalfa, Mesilla and Wilson, were the least susceptible to SPW numbers and CUF101 was the most susceptible.

A negative correlation exists between numbers of SPW adults on cotton and increased distance from epidermal leaf tissues to phloem tissue, and a positive correlation between numbers of SPW adults and decreased thickness of mesophyll tissue layers. These data provide a preliminary basis for increased plant breeding investigations to incorporate these characters into acceptable cultivars for SPW management.

Differences in yield and numbers of SPW adults and nymphs in Texas were noted between melon cultivars. Those with low SPW numbers late in the season produced higher yields. Host suitability may be affected by age.

The La 1340 accession of tomatoes was nearly immune to SPW and had the highest density of type IV trichomes which determines the amount of exudate, and therefore stickiness per leaf. Some tomatoes have less tomato mottle virus which may indicate tolerance to SPW.

F. Integrated Techniques, Approaches and Philosophies

Chairs: Jose M. Amador and Donald Nordlund

Committee Members: R. Carruthers, R. Frisbie, E. DelFosse, R. Riley, and L. Knutson

1. Abstracts
2. Table F
3. Research Summary

INVESTIGATOR'S NAME: J. C. Allen, P. A. Stansly, D. J. Schuster, (FLA), D. G. Riley (TX), T. M. Perring (CA)

AFFILIATION & LOCATION: University of Florida and University of California

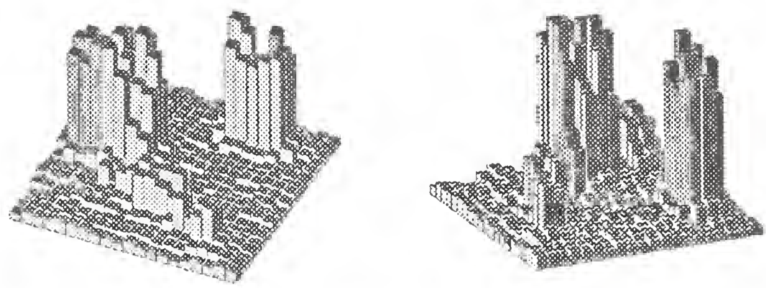
RESEARCH & IMPLEMENTATION AREA: Section F: Integrated Techniques, Approaches and Philosophies

DATES COVERED BY REPORT: July 1 1992 - present

We are developing a project to use computers to display data and simulate SPW movement and reproduction in crop ecosystems on a large spatial scale. Our approach is to gather and display data on existing SPW surveys from CA., TX, and FL using Geographic Information System (GIS) software. Using survey data, we are parameterizing simple models of SPW growth and movement and crop growth. We have a simple version (not yet parameterized to specific crops) of the computer projection program for SPW over a 2-dimensional grid of crops. The crop grid can represent any 2-d arrangement of crops and/or "natural" vegetation coded as an ASCII character file of integers: 1, 2, 3..., (representing the crop types) which can be entered either through the program or with any ASCII editor (e.g., WP or the DOS Edit command). The SPW densities are illustrated as height of a dynamic 3-d bar graph above the crop grid (crops are represented by different colors). Below is an example of a 20 x 20 grid of 3 crops and 2 different views of the simulation frozen at one point in time:

```
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 2 2 2 2 2 1 1 1 1 1 3 3 3 3 3 1 1 1
1 1 2 2 2 2 2 1 1 1 1 1 3 3 3 3 3 1 1 1
1 1 2 2 2 2 2 1 1 1 1 1 3 3 3 3 3 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 3 3 3 3 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1
1 3 3 3 3 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1
1 3 3 3 3 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1
1 3 3 3 3 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 2 2 2 2 2 2 2 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 2 2 2 2 2 2 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 2 2 2 2 2 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

20 x 20 Crop Grid



2 Different View Angles

While we are not too far along yet with actually parameterizing particular crops and SPW on those crops, we are developing data sets from the participating states, and the necessary software is undergoing parallel development. We estimate that within about 6 months we should be able to begin projecting SPW in actual crop map systems for comparison with observed movement. Once this begins, we can start checking the model in field trials and demonstration plots. Ultimately we would like to investigate crop spatial patterns and timing for vulnerability to invasion by SPW and thus be able to suggest changes in current practice to reduce the SPW problem.

INVESTIGATOR'S NAME(S): Robert Flanders, Michael Oraze, Joseph Hancock and Earnest Delfosse

AFFILIATION & LOCATION: USDA, Aphis OA, National Biological Control Institute (NBCI), Federal Building, Rm 539, 6505 Belcrest Rd., Hyattsville, MD 220782

RESEARCH & IMPLEMENTATION AREA: Section F: Integrated Techniques, Approaches and Philosophies

DATES COVERED BY REPORT: June -December 19992

During 1992 (Year 1), the NBCI set up and began operating an electronic Bulletin Board System (NBCI BBS). The NBCI BBS was designed to expedite exchange of biological control information, particularly for such nationally significant projects like sweetpotato whitefly(SPW). Some of its features are: a calendar of meetings and events; announcement of available resources, positions and grants; meeting and newsletter reports; electronic mail; teleconferencing; and various on-line databases. Access to the NBCI BBS is through a toll free, 800 telephone number with any computer equipped with a modem. The complete telephone number is 1-800-344-6224. The NBCI BBS is on-line 24 hours a day, 7 days a week.

Although the NBCI BBS was fully operational beginning in July, very few users have accessed the system. We have been extensively advertising and promoting the use of the system, but usage has been slow to expand. This is typical of the beginning stage of any new BBS. With increased usage, the NBCI BBS will become more attractive to new as well as veteran users.

A "Forum" area dedicated to SPW news and information exchange was set up on the NBCI BBS. Eventually, meeting reports, research highlights, news highlights, etc. will be available on this forum. Users will be able to upload and download information in the SPW Forum. When usage of the BBS increases, the forum area will become one of its more important areas. Note that any information on SPW is welcome on the system and is not restricted to biological control.

Databases are also being developed for the NBCI BBS. This activity has been delayed because of some difficulties in employing a qualified database manager. A relational database to track the foreign collection, importation, rearing, and release of SPW natural enemy species and geographic strains is now being developed and should be available for use during 1993.

INVESTIGATOR'S NAME(S): R. E. Frisbie, N. C. Toscano, P. A. Stansly, R. D. Oetting, P. E. Ellsworth

AFFILIATION & LOCATION: Texas A&M University, University of California at Riverside, University of Florida, University of Georgia, and University of Arizona

RESEARCH & IMPLEMENTATION AREA: Section F: Integrated Techniques, Approaches and Philosophies

DATES COVERED BY REPORT: November, 1992-January, 1993

A sweetpotato whitefly action team (SWAT) of Cooperative Extension Service entomologists representing the major states impacted by the sweetpotato whitefly (SPW) has been formed. Members include the above investigators as well as Drs. Eric Natwick and Peter Goodell from the California Cooperative Extension service. The SWAT has been successful in obtaining an Extension Service USDA grant titled "A Multi-State Coordinated Approach for the Management of the Sweetpotato Whitefly." The grant was awarded late in 1992 in order to develop a multi-state, cooperative mechanism for the joint planning and development of generic educational material to implement an IPM approach to SPW management. the SWAT organized under this grant will link not only the states involved, but also will link with ongoing state and USDA research and regulatory programs. The objectives of the project are: (1) Form a multi-state SWAT of cooperative Extension Service specialists that will be linked to existing state and national research SPW research programs; (2) Develop a multi-state plan to address the 1993 SPW crop problems using existing IPM options; (3) Develop educational material for the Extension Service, farmers and private consultants for SPW management; (4) Begin the formulation of a long-term IPM approach to the SPW.

INVESTIGATOR'S NAME: M. R. Nelson and T. V. Orum

AFFILIATION & LOCATION: Plant Pathology, Univ. of Ariz. Tucson

RESEARCH & IMPLEMENTATION AREA: Section F: Integrated Techniques, Approaches and Philosophies

DATES COVERED BY REPORT: August 1991 - November 1992

Work continues on the application of geographic information systems (GIS) /geostatistics technology to the regional analysis of *Bemisia tabaci* populations in relation to the virus diseases it transmits. Particular attention has been paid to developing a quantifiable procedure for measuring the impact of crop sequencing and the spatial arrangement of cropsboth on whitefly populations and the viruses. Crops in 2571 fields in 391 quarter sections were identified every three weeks from September 1991 to June 1992 in the Yuma Valley in Southwestern Arizona. In addition, data was taken on insect vector population in 43 locations and virus incidence in lettuce, cucurbits and cotton. The Yuma area served as an experimental pilot project for the application of this technology. In a cooperative project with USDA APHIS and David Byrne, University of Arizona, we have obtained and analyzed whitefly abundance data from 938 locations throughout Arizona where traps were placed in the vicinity of cotton fields. Records were also kept from these locations on cotton crumple leaf virus occurrence.

INVESTIGATOR'S NAME: David G. Riley

AFFILIATION & LOCATION: Texas Agricultural Experiment Station
2415 E. Hwy 83, Weslaco, Texas 78596

RESEARCH & IMPLEMENTATION AREA: Section F: Integrated Techniques, Approaches and Philosophies

DATES COVERED BY REPORT: March 1992 - June 1992

Although the severity of the sweetpotato whitefly (SPWF) problem is generally known, relatively little work has been done to quantify the relationship between SPWF numbers and effects on yield for individual crops. In 1991 in the Lower Rio Grande Valley (LRGV) of Texas millions of dollars in vegetable and cotton production were known to be lost due to this pest because of the obvious damage from extremely high numbers of SPWF. However, the actual direct loss to agricultural production in the LRGV was difficult to estimate because an accurate estimate of the overall whitefly population density in production areas was not available, but more importantly, the relationship of whitefly infestation level to yield had not been established. The goal of this research was to estimate an injury level for the SPWF in melons by: (1) investigating the relationship between crop damage and SPWF infestation level for cantaloupe and (2) determining a preliminary insecticide action threshold for sweetpotato whitefly on melons based on adult or nymph counts on the underside of melon leaves.

Numbers of immature SPWF peaked in late April, mid to late May and began to increase again in mid June. Overall, a significant gradient in SPWF infestation was established allowing us to measure the relationship of SPWF numbers and effects on yield. An increase in total numbers of immature SPWF was associated with a decline in harvested melon weight, a decline in number of boxes, and increase in the size category number or number of fruit per box (which means a decrease in fruit size), a decrease in sugars, and increases in sooty mold and downy mildew. The relationship of different stages of SPWF with yield parameters suggest that certain SPWF stages provides a better indicator of SPWF effects on yield than other stages. Using regression analysis and comparing R^2 values for the regression models it was possible to determine which type of SPWF sample best predicted changes in Harvest quality. For example, large SPWF nymph numbers provided a more precise index of effect on overall melon weight and % sugars than all other immature stages combined. Large nymphs also provided a good indicator of effects on melon size, % sooty mold, downy mildew, and number of boxes harvested. SPWF adult numbers on leaves was a better indicator for effects on harvested weight, but was not as good for predicting effects on size, sugars, sooty mold or downy mildew.

The type of relationship between SPWF and certain harvest quality measurements are clearer from the results of these tests. For example numbers of SPWF immature stages and % sooty mold appeared curved rather than linear. Also the amount of variation explained by the regression was high for factors directly affected by the presence of SPWF, for example sooty mold and % sugars, but was less for overall harvested weight and number of boxes. Since size of melons was strongly affected by increased SPWF numbers, but total weight was affected to a lesser degree, it is possible that the plant compensates for increased SPWF damage by producing greater numbers of smaller fruit so that the overall weight is not strongly affected.

The first estimates at an action threshold for SPWF adults per leaf (3rd node from terminal growing point) and large nymphs per 6.7 cm^2 (approximately one square inch) of leaf area based on the average population density which resulted in 10% reduction in numbers of boxes per acre and 10% loss in other harvest quality parameters. Based on these preliminary results thresholds of approximately 1 large nymph per square inch of leaf area sampled at the 6th node or 3 adults per leaf sampled at the 3rd node should be evaluated. It is expected that the threshold will differ between early season and late season infestations.

TABLE F. Summary of Research Progress for Section F - Integrating Techniques, Approaches and Philosophies in Relation to Year 1 Goals of the 5-Year Plan.

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	Progress Achieved No	Significance
F.1 Risk Assessment.	Identify a National evaluation panel to characterize risk assessment information needed for producers and the environment. Design risk assessment procedures for whitefly virus.		X	Studies have been initiated to quantify SPW population levels and melon yields in Texas. Large SPW nymph numbers appear to provide the best index for relationships to yield and to quality measurements. First estimates suggest one large nymph/6.7 cm^2 of leaf at the 6th node or three adults/leaf at the 3rd node should be suspect. Economic thresholds for SPW on melons demonstrates potential for similar thresholds on all major crops as a basis for SPW management. No National evaluation panel to characterize risk assessment needs and procedures has been formed, however.
F.2 Spatial Analysis and GIS.	Establish a national center to coordinate a national network of spatial analysis with GIS capabilities. Determine information needs for SPW.		X	Crop sequencing and spatial arrangement studies are being conducted on an area-wide geographical basis in AZ to identify SPW movement and virus spread. Also, survey data from CA, TX, and FL is being displayed on a GIS system. These studies demonstrate the value of regional and areawide monitoring for management planning, forecasting and strategy development. No National center to coordinate a national network of spacial analysis with GIS capabilities has been established, however.
F.3 Ecosystem modeling.	Establish a National ecosystem model plan to identify scale and attributes of components. Interface with network.		X	Survey data from CA, TX, and FL are being parameterized and simple models of SPW growth and movement and crop growth have been developed. Ultimately this model should permit the development of cropping systems that are resistant to SPW. No National ecosystem model panel has been established, however.
F.4 Networks.	Test and run NBCI bulletin board. Expand network to international dimensions for biological control information exhibition. Expand written materials and workshop presentations. Bring GIS up on networks.		X	The NBCI bulletin board is on line, has been tested, and SPW related data and E-Mail are available. However, the network has not been expanded to international dimensions and GIS is not on the network.

TABLE F - Continued

Research Approaches	Year 1 Goals Statement	Progress Achieved Yes	No	Significance
F.5 Integrated Extension Programs.	Identify existing task-force or action groups and link them into a communication network; written, electronic, radio and conferences. Support and expand information network, newsletters, news articles, video conferences. Interface with appropriate National and State crop programs.		X	Existing task-force or action groups have been identified and the development of communication links is in progress. Preparation of additional training material is in the planning stage. The information network is expanding. This will facilitate the rapid transfer of research information to extension personnel and producer groups.

RESEARCH SUMMARY

Section F: Integrated Techniques, Approaches and Philosophies

Compiled by
J. Amador and Donald A. Nordlund

Integrated pest management (IPM) systems are developed through integration of a variety of control/management techniques. Most researchers are specialists, however, and without an effective network, integration of research results from various specialties into complex management systems is difficult at best. Thus, Section F of the 5-year plan was developed to encourage the timely development of networks, facilitating the integration of research results into effective IPM programs for the SPW. Though progress was made under each of the research approaches for Section F, none of the goals listed for year 1 of the 5-year plan has been fully accomplished. None of the National Panels or Coordination Centers have been established, even informally. Integration of techniques, approaches and philosophies is a new area with no history of funding. Thus, resources available to this activity have been limited. Also, and in part because of limited resources, "champions" for the listed research approaches have not emerged.

F.1. Risk Assessment

SPW populations have been correlated with injury levels and melon yields in the Lower Rio Grande Valley of Texas. Preliminary results indicate that population levels of approximately 1 large nymph per 6.7 cm^2 of leaf area at the 6th node or 3 adults per leaf at the 3rd node can cause measurable losses. Large SPW nymphs appear to provide the best index for relationships to yield and quality measurements. The development of economic thresholds for SPW on melons demonstrates the potential for the development of similar thresholds on all major crops as a basis for SPW management. The establishment national evaluation panel to characterize risk assessment information and the design of risk assessment procedures for whitefly vectored virus, however, were not accomplished.

F.2. Spatial Analysis and GIS

GIS/geostatistics technology were applied to the regional (Yuma Valley) analysis of SPW populations in relation to the virus diseases it transmits. Crops in over 2500 fields were identified every three weeks from September 1991 to June 1992. Data were also taken on insect vector populations in 43 locations and virus incidence in lettuce, cucurbits and cotton. Also, data from surveys of SPW populations in CA, TX, and FL have been displayed using GIS software. The establishment of a national center to coordinate a national network of spatial analysis with GIS capabilities was not accomplished.

F.3. Ecosystem Modeling

Survey data from CA, TX, and FL are also being parameterized and simple models of SPW growth and movement and crop growth have been developed. The ultimate goal of this project is to provide an understanding of crop spatial and timing patterns for vulnerability to invasion by SPW and thus, allowing the development of cropping systems that reduce the impact of SPW. The establishment of a national ecosystem model panel to identify scale and attributes of components for the model was not accomplished.

F.4. Networks

The NBCI bulletin board is on-line and tested. Some material has been placed on the board and E-mail, to facilitating networking, is available. Plans have been made to add additional material to the board. Extensive efforts have also been made to publicize the existence of the board. The bulletin board has not been expanded to an international dimension and GIS is not available on the network.

F.5. Integrated Extension Programs

The USDA-ES has made a grant available for the development of extension materials that will facilitate the flow of available information between researchers, extension educators, producers and commodity groups. The support will be used to develop the following:

- A slide program with accompanying cassette to highlight current research status and management recommendations.

- A high quality video program and a comprehensive manual, with the same objectives as above.

- The implementation of a national network of extension entomologists and plant pathologists working on the reduction of SPW caused damage. In addition, existing task-force or action groups have been identified and the development of communication links is in progress.

IX. OVERVIEW AND RECOMMENDATIONS

The sweetpotato whitefly 5-Year National Research and Action Plan established the framework for a State, Federal agency, Agricultural Experiment Station and industry team effort to provide short- and long-term solutions leading to the development of socially and environmentally acceptable sweetpotato whitefly management systems.

The plan identified research priorities and outlined specific research approaches with temporarily attainable goals within the available resources allocated to accomplish the research. The annual review process functions to analyze and evaluate progress made in reaching the Plan's defined goals, but of equal importance, reexamines directions of research and priority focus, with the purpose of re-establishing initial priorities or making appropriate changes or new priorities based on current knowledge. It also falls within the purview of the review team to identify deficiencies in the research that can be addressed with redirections of current resources or supplemented with new resources.

Reports of progress and discussions within the forum of the review workshop indicate that significant progress has been made within each of the research areas in the plan.

A. ECOLOGY, POPULATION DYNAMICS AND DISPERSAL

Intensive field surveys are defining the extensive uncultivated and cultivated host range of the sweetpotato whitefly that support the continuity and growth of populations through inter- and intra-host movement. The activity of natural enemies is extensive in some of these host systems and abiotic factors such as temperature may limit population development in more northern latitudes. Some biological and ecological factors affecting sweetpotato whitefly dispersal have been identified and along with quantitative estimates of dispersal rates and may provide a basis for development of regional crop management strategies. Development of adult and immature sweetpotato whitefly sampling methods progressed favorably in field and greenhouse crops and are critical components of pest management programs. Some progress has been made in establishing economic thresholds in melons, but there has been little progress in developing economic thresholds or effective sampling methods for "sticky cotton". The goals, formal structures, and some of the necessary data have been identified for modeling efforts. Detailed life process models and more general spatial models are being developed to integrate the influences of abiotic and biotic factors on site-specific and regional population dynamics.

Recommendations

1. Continue research on host plant interactions. Conduct demographic (development, survival, fecundity) studies of SPW on major host plants identified under A.1, Year 1. Hosts should include cotton, cucurbits, tomatoes, alfalfa, ornamentals, and major weed species.

2. Expand host plant studies to determine seasonal cycles and characterize host associations of SPW transmitted viruses.

3. Encourage researchers to standardize sampling methods to the degree possible: Report adult trapping data on per unit basis, report correlations of adult to immature counts, report captures on a standard trap (flat sticky-card oriented horizontally at canopy height) in all studies utilizing other adult sampling methods to facilitate direct comparisons between studies on the same and different hosts.

4. Expand efforts and resources to develop efficient sampling plans and economic thresholds for major host crops. Include physiological effects of SPW feeding, virus transmission and consequences of honey-dew production.

5. Combine Research Approaches A.5 and A.6 into a unified A.5 entitled 'Determine factors influencing SPW dispersal and impact of dispersal on population dynamics in greenhouse, field crops and weed host systems'. Continue effort to characterize and quantify SPW flight behavior and dispersal.

6. Expand cooperation and collaboration between research and modeling efforts so that models encompass our most current knowledge of SPW population dynamics and can play a role in defining new areas of needed research.

B. FUNDAMENTAL RESEARCH

The 5-year plan placed high priority on the need for fundamental research in areas of physiology, morphology, biochemistry and systematics to provide a base for innovative and new approaches to development of management strategies. Morphological structure investigations of the SPW mouthparts and their role in feeding, virus acquisition and transmission, identification of amylase in SPW, physiological functions of water loss and oxygen consumption, further elucidation of the complexities of the honeydew sugar components and various morphological similarities and differences in A and B SPW biotypes has increased our knowledge of the insect. This information may lead to an understanding of factors affecting SPW functions that may be exploited in management strategies.

A growing amount of evidence relating DNA structure, esterase system analysis, isoelectric focus techniques and biological studies suggest major differences in A and B biotypes. rRNA analyses suggest conspecific association. Also, SPW have been identified that appear to be A/B hybrids. These differences need to be resolved.

Virus-vector interactions, geminivirus identification and characterization, as well as research to define SPW physiological disorders, has been initiated to place perspective on the increasing scope of the plant disease problem in the agricultural community.

Recommendations

1. Resolve A, B biotype-species issue.

2. Increase research effort in fundamental areas of physiology, biochemistry, morphology and behavioral science.

3. Intensify efforts in virus-vector relationships, virus identification and characterization.

4. Define role of SPW in physiological plant disorders.

C. CHEMICAL CONTROL, BIORATIONALS AND PESTICIDE APPLICATION TECHNOLOGY

The national effort to evaluate candidate insecticides and biorationals for SPW control on major cultivated crops proved to be a highly successful endeavor. Equally productive were efforts to develop improved application technology. Several insecticides and/or insecticide combinations were identified as exceptionally promising, and with new or improved application methods by ground or air, better coverage in target

underleaf areas may be obtained. Preliminary analysis shows the need for expanded insecticide resistance management, genetics of resistance, economic threshold and effects on natural enemy research.

Recommendations

1. Focus insecticide evaluations on rates, frequency, placement and timing of application studies with the most promising materials.

2. Initiate insecticide rotation studies and determine impact on natural enemies.

3. Expand resistance management research and initiate genetics of resistance studies.

4. Continue efforts and evaluations of application equipment to improve delivery of chemicals to leaf target areas.

D. BIOLOGICAL CONTROL

Research reports suggest extensive effort in biological approaches to SPW control. Data support the existence of high levels of indigenous natural enemy activity in certain ecosystems, suggesting that augmentation and conservation approaches are important avenues of exploitation in SPW management. A monoclonal antibody has been developed to quantify the role of predation in SPW population regulation as well as determine candidate predator potential. Identification of numerous potential pathogenic fungi and the more experimentally advanced *Beauveria bassiana* appear to be good candidates for further study. The number of introduced exotic natural enemies is impressive. Extensive evaluation to determine efficacy, compatibility, habitat adaptability and other factors is essential for optimum utilization of the introduced material.

Recommendations

1. Continue research to define the role of indigenous natural enemies in regulating SPW populations.

2. Investigate the potential of identified fungal pathogens.

3. Continue biological and ecological adaptability studies with exotic natural enemy species to identify candidates with the best potential.

4. Establish extensive research and monitoring systems to evaluate impact of exotic natural enemy releases.

E. CROP MANAGEMENT SYSTEMS AND HOST PLANT RESISTANCE

Limited studies with water management systems in cotton suggest that SPW populations were higher in stressed cotton. Overhead sprinkler irrigation in melon cultures appear also to adversely affect population development. These data indicate that more effort needs to be placed on other cultural practices that influence plant growth and development interaction to determine SPW relationships.

More extensive studies conducted to identify SPW resistance in several crop types as well as tomato mottle resistance have revealed the existence of potentially useful germplasm.

Recommendations

1. Expand research to evaluate water relations, plant growth regulators, fertilizers, planting dates and other factors affecting plant growth and development in relation to SPW population development.

2. Initiate classical breeding and other genetic approaches to incorporate SPW and virus resistance into acceptable agronomic crop types.

F. INTEGRATING TECHNIQUES, APPROACHES AND PHILOSOPHIES

Within the framework of the 5-year plan, efforts to integrate risk assessment information, spatial analysis and GIS, networking, ecological modeling, and extension programs has progressed, but at less than the expected rates of accomplishment. There is tremendous opportunities in the area of Integrated Techniques, Approaches and Philosophies. However, since this is a new area (one which is primarily administrative in nature) of activity and one with no history of funding, resources dedicated to integration are limited. This has impeded essential progress. Therefore, to insure that progress continues at an acceptable rate, it is essential that "champions" for each of the Research Approaches emerge and be supported.

Recommendations

1. Most of the Research Approaches for Section F require the establishment of some panel or coordination center at the national level. Yet, networking itself requires voluntary participation. We believe that progress could be accelerated if a "champion" is identified and supported for each of the Research Approaches. The committee has asked the following individuals, and they have agreed, to serve as champions:

   M. R. Nelson - Risk Assessment
   D. Haynes - Spatial Analysis and GIS
   J. Allen - Ecosystem Modeling
   B. Flanders - Networks
   R. Frisbie - Integrated Extension Programs.

2. Research initiation funds should be made available to permit the development of comprehensive research grant proposals for integration of techniques. D. Kopp requested that such a proposal be prepared and submitted to the USDA-ES. J. Allen and D. Haynes have agreed to prepare this proposal with the objective of identifying and bringing together experts in the area to facilitate development of a comprehensive national research proposal for ecosystem modeling of the SPW.

3. The 5-year plan needs budgetary supervision if it is to be effective. Sources of funds should be identified for competitive and solicited grants. Some areas of the plan will be emphasized by existing activities or research programs while others will be too broad to be utilized within one research center. Efforts must be made to supervise the 5-year action plan to provide budgetary assistance in areas underfunded.

4. Section F is responsible for integration of research results from all of the other Sections in the 5-year plan. To accomplish this task, the committee members in Section F must be able to interact with the other Sections. The existing meeting format (concurrent breakout sessions) does not facilitate this necessary interaction. We recommend extensive use of posters at the next meeting, to facilitate 1 on 1 communication between individual researchers, extension personnel, and administrators. Industry presentations should also be made via posters. After the poster sessions, each Section could present an integrated highlight progress report. Another possibility is to have current issues sessions where a pannel interacts with the audience.

X. APPENDICES

APPENDIX A. Program Review Meeting Agenda

PROGRESS REVIEW OF THE 5-YEAR NATIONAL RESEARCH AND ACTION PLAN FOR DEVELOPMENT OF MANAGEMENT AND CONTROL METHODOLOGY FOR SWEETPOTATO WHITEFLY, *Bemisia tabaci* Gennadius

Program Coordinators:

T. J. Henneberry
USDA-ARS, Phoenix, AZ

N. C. Toscano
Univ. of CA, Riverside

January 18-21, 1993
Radisson Mission Palms Hotel, Tempe, AZ

MEETING AGENDA AND ASSIGNMENTS

MONDAY TRAVEL DAY

1:00-6:00 Registration--Ballroom Foyer

4:00-6:00 SPW Planning Committee Meeting
Organizers, R. M. Faust and J. R. Coppedge - *Colonnade Room*

TUESDAY MORNING

Sweetpotato Whitefly Problem and Perspectives

7:00-8:00 Registration and **Continental Breakfast** - *Ballroom*

8:00-8:10 Welcome, Administrative Details
T. J. Henneberry & N. C. Toscano

8:10-8:20 Introduction
R. M. Faust

8:20-8:30 Meeting Goals and Objectives
J. R. Coppedge

Agency Considerations and Outlook
Presiding: T. J. Henneberry & N. C. Toscano

8:30-8:45 U.S. Department of Agriculture
Mary Carter, ARS

8:45-8:55 Agency Communication and Information Exchange
R. Riley, CSRS

8:55-9:35 Cotton, Vegetable, Nursery and Ornamental Industries
Frank Carter, National Cotton Council
Gina Antoniotti, Poinsettia Growers
Cliff Chambers, Vegetable Producers

9:35-9:45 Agricultural Chemicals Industries Perspective
Ray McAllister, NACA

9:45-10:00 Economic Impact on Farm Communities
Jerry Siebert, Univ. of CA, Berkeley

10:00-10:10 State Agric. Experiment Stations
Colin C. Kaltenbach, Univ. of AZ

10:10-10:30 **Coffee Break**

Research and Action Plan Progress Highlights
Presiding: N. C. Toscano

10:30-10:50 Section A: Ecology, Population Dynamics and Dispersal
Co-Chairmen - S. Naranjo, ARS and H. Browning, Univ. of FL
Committee: G. Nuessly, D. Byrne, T. Perring, M. Parella and H. Costa

10:50-11:10 Section B: Fundamental Research--Behavior, Biochemistry, Biotypes, Morphology, Physiology, Systematics, Virus Diseases, and Virus Vector Interactions
Co-Chairmen - R. Mayer, ARS and J. Brown, Univ. of AZ
Committee: K. Hoelmer, J. Duffus, M. Houck, D. Hendrix, and D. Jimenez

11:10-11:30 Section C: Chemical Control, Biorationals and Pesticide Application Technology
Co-Chairmen - N. Toscano, Univ. of CA, Riverside, and J. Palumbo, Univ. of AZ, Yuma
Committee: J. Neal, D. Akey, P. Stansly, F. Sances and D. Wolfenbarger

11:30-11:50 Section D: Biocontrol
Co-Chairmen - L. Osborne, Univ. of FL and L. Wendel, APHIS
Committee: W. Jones, T. Bellows, A. Cohen, R. Creamer and M. Rose

11:50-1:15 **Lunch**

TUESDAY AFTERNOON

Research and Action Plan Progress Highlights (Continued)
Presiding: J. Coppedge

1:15-1:35 Section E: Crop Management Systems and Host Plant Resistance
Co-Chairmen - D. Hardee, ARS and J. Still, ARS
Committee: H. Flint, D. Riley, J. Norman, D. Schuster and J. Silvertooth

1:35 - 1:55 Section F: Integrated Techniques, Approaches, and Philosophies
Co-Chairmen - J. Amador, TX A&M and D. Nordlund, ARS
Committee: R. Carruthers, R. Frisbie, E. DelFosse, R. Riley and L. Knutson

1:55-2:15 **Coffee Break**

Research Results Exchange and Planning Sessions
Open Sessions - Presiding: Section Chairs

2:15-4:30 Sections A, B, C, D, E, and F
Concurrent meetings to exchange intensive research information, establish priorities for immediate and long-range research implementation

Section A - *Colonnade Room*
Section B - *Joshua Tree Room*
Section C - *Campanile Room*
Section D - *Cavetto Room*
Section E - *Sand Lotus Room*
Section F - *Wind Flower Room*

4:30-7:00 **Dinner Break**

TUESDAY EVENING
Presiding: D. Akey and N. C. Toscano

7:00 Dessert and Coffee Bar - *Ballroom*

7:00-7:15 Principles of Insecticide Resistance Management
T. Miller, Univ. of CA, Riverside

7:15-10:00 New Developments from Industry
Agenda Coordinators - N. Toscano, D. Akey, L. Osborne and D. Hardee

WEDNESDAY MORNING

Research Results Exchange and Planning Sessions (Continued)

Open Sessions - Presiding: Section Chairs

7:30-8:00 Continental Breakfast - *Ballroom*

8:00-10:00 Sections A, B, C, D, E, and F
Concurrent meetings to exchange intensive research information, establish priorities for immediate and long-range research implementation.
Same breakout rooms as before.

10:00-10:30 **Coffee Break**

Section Reports - short- and long-term research initiatives based on research progress results
Presiding: R. M. Faust

10:30-10:50 Section A: Ecology, Population Dynamics and Dispersal

10:50-11:10 Discussion

11:10-11:30 Section B: Fundamental Research - Behavior, Biochemistry, Biotypes, Morphology, Physiology, Systematics, Virus Diseases and Virus Vector Interactions

11:30-11:50 Discussion

11:50-1:00 **Lunch**

Section Reports - short- and long-term research initiatives based on research progress results
(Continued)
Presiding: R. Carruthers

1:00-1:20 Section C: Chemical Control, Biorationals and Pesticide Applied Technology

1:20-1:40 Discussion

1:40-2:00 Section D: Biocontrol

2:00-2:20 Discussion

2:20-2:40 **Coffee Break**

2:40-3:00 Section E: Crop Management Systems and Host Plant Resistance

3:00-3:20 Discussion

3:20-3:40 Section F: Integrated Techniques, Approaches and Philosophies

3:40-4:00 Discussion

4:00-4:15 Wrap-up Discussion, Suggestions - N. C. Toscano and T. J. Henneberry

4:15 **General Session Adjourned**

4:30-5:30 Executive Committee Meeting
Co-Chairmen, Committees, Etc.
Ballroom

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APPENDIX C. Special Session on New Developments from Industry

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Summaries of *New Developments From Industry* Relating To The Sweetpotato Whitefly (SPWF) *Bemisia tabaci*

PRESENTED JANUARY 19, 1993
(Edited by D. H. Akey)

CIBA-GEIGY CORP., CIBA PLANT PROTECTANTS, J. J. Zaccaria, Bakersfield, CA

Fenoxycarb is a non-neurotoxic insect growth regulator that has ovicidal activity and interferes with the molting of early larval and nymphal stages, and progression to the adult stage. Fenoxycarb shows excellent activity against several whitefly genera including: *Bemisia Trialeurodes*, and *Aleyrodes*. It is very active against eggs and immature stages, but has no effect against adult insects. Fenoxycarb has been non-phytotoxic on numerous vegetable, field, and ornamental crops and exhibits very low toxicity to mammals, birds, fish and beneficial insects. Toxicology studies show that it is not mutagenic, teratogenic, oncogenic, nor a reproductive toxin. Fenoxycarb has low environmental mobility, no bioaccumulation tendency in fish, little potential for environmental persistence and rapid dissipation in soils and plants. It is presently registered by EPA and Cal-EPA as Award, a brand of Logic Fire Ant Bait, for use in non-crop areas. Fenoxycarb is currently not registered for any food crop uses. Ciba-Geigy is currently pursuing full registrations for food crops.

CGA-215944 is a new systemic insecticide from a novel type of chemistry (asymmetric triazinone) with a new mode of action. It is active against whiteflies, aphids, and other sucking insects in vegetables, ornamentals, field crops, cotton, deciduous fruits, and citrus. The recommended rate of application is 0.125 to 0.25 ai/acre depending on the pest and crop. CGA-215944 has a low mammalian acute toxicity and is safe to beneficials, bees, fish and birds. It has a half life of 3 days in soil. CGA-215944 is under full development in the U.S. and abroad.

DOW ELANCO, Jesse Richardson, Hesperia, CA

Lorsban 4E and 50W (Chlorpyrifos) has the potential for controlling SPWF in cotton and vegetable crops. Preliminary research suggests that Lorsban alone or tank mixed with a pyrethroid can provide equal or better control than other organophosphates alone or tank mixed with a pyrethroid.

DUPONT AG PRODUCTS, Jeffrey Pacheco, Phoenix, AZ

Dupont Ag Products offers a number of SPWF control agents. Vydate (the carbamate, oxamyl) is offered in 2 formulations, C -LV as a cotton only insecticide [not in CA] and "L" as an insecticide/nematicide for cotton [including CA] and some vegetables. Lannate (the carbamate, methomyl) has activity against SPWF and may fit in combination with other compounds. Also, both Vydate and Lannate are effective against cotton aphid. Asana (the pyrethroid, esfenvalerate) has been effective in tank mixes against high population pressures of SPWF. Biobit (the biological agent, *Bacillus thuringiensis*, BT) is available for use against pests other than SPWF as part of resistance and chemical rotation management schemes.

ELECTROSTATIC SPRAYING SYSTEMS, Steve Cooper, Watkinsville, GA

A chemical sprayer has recently been introduced which uses a technology called "air-assisted electrostatics". The system is simple in design and is capable of significantly increasing insect and disease control on crops while also reducing the amounts of water and agrichemicals applied. The sprayer is also instrumental for growers in the transition to using lower-toxicity chemicals which are not harmful to the environment. Electrostatic sprayers reduce waste and off-target drift by over 50%. Air-assisted electrostatic sprayers produce electrically charged spray droplets which are carried into the plant canopy in a high speed air-stream. The result is more than twice the deposition efficiency of hydraulic sprayers and non-electrostatic types of air-assisted sprayers. The benefits are optimized insect and disease control along with significant reductions in application costs. ESS produces several types of electrostatic sprayers for agricultural pesticides. Hand-held mist sprayers and timer-operated automatic fogging systems are well suited for greenhouses. For field crops, several sizes of 3-point hitch units have recently been introduced.

FEROMONE CORP., Al Knauf, Dallas, TX

Naturalis bioinsecticides are formulations containing conidial suspensions of *Beauveria bassiana* (ATCC 74040). In 5 years of laboratory, greenhouse, field and commercial trials on field crops and ornamentals, these bioinsecticides have provided control of boll weevil, cotton fleahopper and SPWF whether applied alone or in IPM programs. Naturalis®-L is the first biorational product which has demonstrated such efficacy.

FMC CORP., James Knabke, El Centro, CA

A new pyrethroid insecticide, FMC-56701 (marketed as fury 1.5 EC in some areas), is now federally labeled for use on cotton. It is a broad-spectrum insecticide that is very effective on many of the insect pests of cotton including pink bollworm, cotton bollworm, tobacco budworm, boll weevil, and many others as well. During the development of this insecticide, university and FMC researchers tested FMC-56701 against the new whitefly that has become a very serious pest of cotton. This whitefly (known as the SPWF, strain B or the silverleaf whitefly) has proven to be very well controlled by combinations of FMC-56701 (.0375 - .05 1b ai/acre) + Orthene (.50 1b ai/acre). The high efficacy of FMC-56701 against many insect pests of cotton will make the combination of FMC-56701 + Orthene very useful in the common situation on cotton where whiteflies and other pests of cotton occur simultaneously.

G & M AGRI. SUPPLY CO., Mark Miller, Scottsdale, AZ

"Row Covers" Spun-bonded polypropylene or polyester are now not just used for frost protection but are now used for insect control via barrier affect as well. Two recent publications report on use of row covers for protection of zucchini from SPWF. The row covers are used for 25 days after planting. Row covers are most effective for high value crops, e.g. tomatoes, cabbage, zucchini, and cantaloupe. Another aspect, due to the frost protection of row covers, may make it possible to plant earlier in the spring or to get additional growth in the fall to have produce available during the time of peak market pricing. Row covers would have to be removed from plants that require pollinization. In most cases, row covers can be used for more than one season.

ICI de MEXICO S.A. de C.V., Juan Perez, Arturo Obando, and Nicholas Darby, MEXICO

Buprofezin, a growth regulator of SPWF nymphs, was evaluated as a preventive management tool, alone or mixed with other insecticides to hold SPWF populations to low levels in cotton. Trials were conducted in Mexicali, B.C.N. Mexico during the 1992 cotton season on Deltapine 80 cotton. Four aerial applications were applied in each management scheme. Each plot consisted of 5 Ha. The most effective treatment was that of preventive management. The order of applications were : 1) buprofezin alone, 2) buprofezin mixed with endosulfan 525, 3) endosulfan 1050 and 4) buprofezin mixed with endosulfan 1050. The preventive management scheme had 5.3% of stained fiber, compared to 13.4% in the conventional management scheme (total stained fiber in both cases). Production data showed preventive management had 4.5 tons lint/Ha and conventional management had 2.4 tons lint/Ha. This was due to lower population levels of SPWF in the preventive management scheme than in the conventional management scheme. The preventive management of SPWF (5-10 nymphs, 10-20 adults/leaf), had better controls through the cotton season than conventional management. Four applications increased control 40% and also reduced the SPWF population during the crop cycle. Production and quality fiber were better.

MILES INC., J. Walter Mullins, Kansas City, MO

Efficacy trials conducted by Miles Inc. and participants in the five year action plan to determine methods for managing the SPWF-strain B or silverleaf whitefly demonstrate the utility of imidacloprid (Proposed Tradenames: CONFIDOR 2F for cotton and vegetables and PROVADO for ornamentals) for whitefly control. Because imidacloprid exhibits a mode of action different than the pyrethroids, organophosphates and organochlorines currently employed for whitefly control, this new active ingredient will be useful in resistance management strategies to maintain the utility of all chemistries currently useful for whitefly control. For vegetables, the current label will recommend soil application rates of .25 to .50 lbs ai/acre, applied as an in-furrow, transplant drench or sidedress application for early to mid season control. For cotton, the current label will recommend .044 lbs ai/acre as a foliar spray. For ornamentals the use will vary depending on the type of ornamental and type of production operation. The ornamental petition was submitted to EPA in March 1992 and registration is expected in 1993. The cotton petition was submitted in November 1992 and the vegetable petition will be submitted by April 1993.

MONTEREY CHEM. CO., Eldon Hart, Fresno, CA

Saf - T - Side is a spray oil emulsion insecticide with a petroleum oil base. Currently, it is labeled on a variety of vegetable, ornamental and tree crops. Registration is pending on numerous other crops. Excellent control has been achieved on white flies, mites, leaf miners, aphids and many other insects, including immature forms, if spray covers the insect.

MYCOGEN CORP., Robert Haygood, San Diego, CA

M-Pede® Insecticide is an effective fatty acid-based insecticide for use in SPWF Control Programs. It effectively controls whitefly immatures, pupae and adults on a wide variety of vegetable, fruit, ornamental and field crops. M-Pede® is a unique formulation of potassium salts of naturally occurring fatty acids which is optimized to control labeled pests on contact without being phytotoxic to plants. Its different mode of action (disruption of insect cuticles and cell membranes), excellent wetting properties and rapid knockdown activity make M-Pede® an effective tank mix companion with many other labeled insecticides for control of whiteflies. Field results generated from 1990 to 1992 demonstrate that a one percent solution of M-Pede® tank mixed with labeled rates of recommended companion products can improve overall control of sweetpotato whiteflies as well as many other soft bodied pest.

NOR-AM CHEM. CO., John Lublinkhof, Wilmington, DE

APPLAUD® is the trade name for the insect growth regulator containing the active ingredient, buprofezin. It is a chitin inhibitor which affects the molting process in the nymphal instars but also affects adults indirectly by suppressing oviposition. APPLAUD is a selective product proving to be effective against homopteran insects such as whiteflies, leafhoppers and scales. It is shown to have negligible effects on beneficial insects and mites. It also has very low toxicity to mammals, birds, fish and crustaceans. APPLAUD is currently registered in approximately fifty countries and is being developed in the U.S. by NOR-AM Chemical Co. in cooperation with Nihon Nohyaku Co., Ltd. in Japan. In 1992, very positive results have been reported with APPLAUD from a number of trials on cotton, melons and tomatoes where SPWF strain B (silverleaf WF) is a major problem.

NOR-AM CHEM. CO., Phil Odom, Phoenix, AZ

Ovasyn®: is the trade name for the insecticide containing the active ingredient, amitraz. It is a chemistry with several applications which can help control whiteflies and aphids by synergizing other compounds when used in combination. Ovasyn is effective on whitefly nymphs and eggs. Ovasyn has been shown to be relatively safe on beneficial insects. Ovasyn® had a Section 18 for use on cotton in 1992 in Arizona for over 400,000 acres. Section 18 requests for 1993 are being sought for use in cotton in Texas, California and Arizona. Registration is anticipated in 1993 for Ovasyn use on cotton.

ROUSSEL UCLAF, Charles Silcox, Montvale, NJ

Results, from field tests across southern states and in laboratory tests with whitefly strains from around the world, indicate that Butacide 8EC (piperonyl butoxide) may play a role in SPWF (silverleaf WF) resistance management. One treatment that needs to be evaluated is the three-way combination of a pyrethroid, an organophosphate and Butacide 8EC. The potential of this treatment lies in its ability to overwhelm the two most important metabolic resistance mechanisms (esterases and oxidases). Theoretically, the pyrethroid and the organophosphate should interact with esterases and the pyrethroid and Butacide 8EC (and perhaps even the organophosphate) should interact with mixed-function oxidases with the end result being a much more susceptible whitefly because both metabolic systems will be disrupted. Consideration should also be given to the use of Pyrenone crop spray and Rotacide EC.

S. HELFFRICH & ASSOC., Stu Helffrich, Phoenix, AZ

COMATE Cotton Oil Products were developed 15 years ago and have become a standard part of insect control programs in the desert areas of Arizona and California. The products have been applied on most crops in the desert areas. In most applications, these cotton oil products have been used as additives and have contributed to pest control by improving deposition, canopy penetration and retention on plant surfaces.

All vegetable oils are composed of various fatty acids - the words "saturated" and "unsaturated" are common in dietary circles today. Based on work done in Canada and the U.S., the fatty acids could have an important position in pest control because of the specific fatty acids present in the different vegetable oils. In 1993, careful consideration and attention will be given to developing a blend of vegetable oils as a new product addition to the COMATE line of products.

SUKUP MANUF. CO., Eugene Sukup, Sheffield, IA

Sukup Manufacturing Company of Sheffield, Iowa, has been testing the concept of using high-velocity fans with a vacuum effect to control insects on the plant foliage of vegetable crops since 1989-- especially on strawberries, grapes and lettuce in California, potatoes in Michigan, Maine, Maryland and Virginia, and grapes in New York. We have vacuumed Chinese lettuce, squash and tomatoes in Florida, chives in Illinois, corn and soybeans in Iowa. Thus, the use of vacuum insect control is as widespread in the areas used as in the types of plants vacuumed. Efficiency realized has been anywhere from 7 to 90% removal of insects with documented tests done in Maine, Michigan and Florida. Our first test with combined spraying and vacuuming was in grapes in New York State. A unit was then designed for staked tomatoes in Florida, where it was very successful in recirculating some of the spray and completely saturating the tomato plant with chemical, which proved to do a superior job to spraying alone.

*SUMITOMO CHEM. CO., by Tom DeWitt (VALENT USA Corp.), Fresno, CA

Pyriproxyfen (S-71639) is not a conventional insecticide but an insect growth regulator (IGR). S-71639 is an IGR which mimics the naturally occurring juvenile hormone (juvenile hormone mimic). S-71639 affects the same receptor sites of insects as methoprene and the natural juvenile hormone. Application to a susceptible insect disrupts the hormonal balance, and causes a failure of ecdysis, lethality, and/or sterility. Depending on insect stage of growth, S-71639 may cause inhibition of metamorphosis, inhibition of embryogenesis, inhibition of reproduction and inhibition of larval development. S-71639 is very effective in controlling a number of insect pests: armored scale, pear psylla, codling moth, oriental fruit moth and several whitefly species including SPWF. S-71639 is currently registered in South Africa, Guatemala and Turkey for control of the SPWF at 20 to 40 grams ai/A. Registrations are pending in Denmark, France, Belgium, Spain and Portugal.

*VALENT USA Corp., Mike Ansolabehere, Fresno, CA

Orthene 90S at 0.5 to 1.0 in combination with various synthetic pyrethroid insecticides has performed well in University and USDA research trials for control of SPWF in cotton. The combination has also been effective commercially. Orthene 90S has full registration in cotton and can be used up to 21 days to harvest.

Danitol 2.4 EC is a synthetic pyrethroid insecticide with unique properties that has provided excellent SPWF control in University and USDA testing when tank mixed with Orthene 90S. Danitol is currently pending EPA registration and could have a cotton registration in time for the 1993 cotton season. Section 18 Emergency Exemptions are also being requested in the AZ and TX cotton growing regions, in the event the EPA registration is not granted in time for the 1993 cotton season. Danitol will also be able to be used up to 21 days before harvest.

W. R. GRACE CO., Jerrold Harris, Columbia, MD

Margosan-O,® a formulation of natural extracts from seeds of the neem tree Azadirachta indica, is a useful pest management product. The key insecticidal ingredient in neem is azadirachtin, a naturally occurring substance that belongs to an organic molecule class called *tetranortriterpenoids*. Margosan-O, through modern technology, captures the insecticidal benefits of azadirachtin in a convenient, stable and highly potent form. Margosan-O in a pest management program controls a variety of pests including whiteflies and thrips. It gives three modes of activity in one product: insect growth regulator, repellency, antifeedant; and carries only a caution label.

APPENDIX D. Whitefly Collection Protocol

Standardized Collection Form to Accompany Whitefly Samples

By

Interagency Collaboration: USDA/ARS; USDA/APHIS; CSRS

For

National Research and Action Plan for Development of Management and Control Methodology for the Sweetpotato Whitefly, *Bemisia tabaci* Genn.
Section B Subcommittee

Cut Here

Collectors' Name: ______________________ Date of Collection: ______________
Collector's Address: ____
____

Season: ☐Summer ☐Autumn ☐Spring ☐Winter

Host Plant: Common name: ______________________________________
Genus ______________________ Species ______________________
Family ____

Place of Collection: Site ______________________ Farmer ______________________
Nearest Town or Village ______________________________________
Nearest City ____
Country ______________________________________ Mail Code ________

Source: ☐field crop ☐greenhouse ☐native plant ☐other ______________________

Stages of Insect on Plant: ☐adult ☐immature instars ☐eggs

Level of Infestation: ☐high ☐medium ☐low ☐occasional insect

Problem Insect: ☐new problem; date and year when first noticed ______________________
☐longterm resident; since what year/date? ______________________

Other Insects Present: ____

Collection Code: Date:________ Sample No.________ Initials of Collector________

APPENDIX E.
Suggested Study Programs for 1993 Insecticide Evaluations

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C. Chemical Control, Biorationals, and Pesticide Application Technology:
Suggested Study Programs for 1993 Insecticide Evaluations to meet Research Approaches C.1 and C.2 for Year 2, Table C[1,2,3]

1) Whole Season Rotational Pesticide Systems.

Apply treatments by ground spray (and aerial spray as control when crop is normally treated by aerial applications). Include adjuvant for all foliar treatments. Use large blocks (e.g. five 5-acre blocks for cotton). Use 5 replicates by strip within each block with 5 samples per replicate. Use every effort to obtain effective underleaf coverage at gallon per acre normally used for the crop (e.g. $\leq$30 gal/acre by ground for cotton). For cotton, use short season varieties, use mipiquat-chloride to manage the cotton canopy if appropriate; and consider ethephon followed by thidiazuron for use as harvest aids. For all crops, monitor natural enemies in crops and crop margins.

a. Example of specific system for harvestable cotton. System uses EPA registered agents and those with Section 18's.

   1. Systemic at seed / side dress; e.g., oxamyl, or acephate, or aldicarb. Also, the latter appears to have a plant growth regulator effect that increases root mass.

   2. A carbamate or organophosphate insecticide at pin-head square against predominate cotton pest of area if necessary; one application only.

   3. BT, diflubenzuron, potassium salts of fatty acids, and labeled oils used as needed, primarily against lepidopterous pests and boll weevil during rest of early season and early and middle of mid-season or until adult SPWF number 1-2 per plant or nymphs number 3-4 per leaf with highest immature population.

   4. When threshold in 3. is reached, amitraz with endosulfan or acephate (latter if aphids present) will be applied twice at weekly intervals.

   5. Pyrethroid, applied 2 times with amitraz, then 2 times alone weekly (or at longer intervals if appropriate).

   6. If appropriate, cotton terminated (4-5 nodes above 1st cracked boll or as appropriate for area).

   7. Cotton harvested expediently and sampled for quality and yield.

b. Example of generalized whole season rotational pesticide systems to conserve natural enemies. Crop-free periods required to reduce SPWF numbers to manageable levels.

   1. Use of imidacloprid early, in soil or at seed, one application. Use "yes/no" decision base on area-wide perception of SPWF activity and anticipated threshold levels.

2. Use of IGR (e.g.; buprofezin if on EUP, or other) early based on adults and eggs present, using a "medium threshold".

3. Use of labeled oils and potassium salts of fatty acids, or detergents (experimental-unlabeled products) based on presence of low populations.

4. Use of agents listed in a. 4. and a. 5. at high population levels or as emergency treatments.

b. Alternate plan, reverse application order of 2 and 3; again based on population levels.

c. Control system to be comprised of "best agricultural practices" used for that crop in that area. Would include aerial applications if appropriate (usually early in crop phenology) and if possible, 5-acre blocks using systems a. and b. would also be used for aerial control comparisons if appropriate and possible.

d. Large untreated check blocks, if possible.

e. Monitor natural enemies in crops and crop margins.

2) Small or large plot trial evaluations and agents to be considered.

A. Agents to be tested alone on in combination:

Bifenthrin (as a standard, FMC Corp)
Deltamethrin (e.g., DECIS via Rhone-Poulenc)
Fenpropathrin (as a standard [now labeled] as Danitol by Valent USA)

Zeta Cypermethrin, FMC 56701EW, (similar to Fury EC but is water-based concentrate) will be named Mustang, already EPA registered/labeled
Zeta Cypermethrin (+ acephate)

Imidacloprid (Miles Agric. Div.)

Buprofezin (Nor-AM Chem. Co.)

Amitraz (labeled) (Nor-Am Chem. Co.)

Azadirachtin compds.:
Margosan O (labeled) (Grace Sierra)
ATI-720S and KDH-0323 (only available per arrangement with AgriDyne Technologies Inc.)

M-Pede (labeled) (Mycogen Corp.)

Soaps & Oils (some oils labeled, e.g. Saf-T-Side, Monterey Chem. Co.; Stylet-Oil, JMS Co.)

Diatomaceous earth

Rotenone (labeled example, Rotacide, Roussel Uclaf)

B. Synergists for tank mix combinations.

Tribufos labeled example as defoliant, DEF (Miles Inc.)

Piperonyl butoxide
labeled example: Butacide (Roussel Uclaf)
labeled example of a dual combination that includes pyrethrin: Pyrenone (Roussel Uclaf)

Example of a three-way tank mix experiment for synergism:

The following scheme is designed to test the possibility of using combinations of a pyrethroid and an organophosphate to interact with esterases and the synergist, piperonyl butoxide, and the pyrethroid (and perhaps the organophosphate) to interact with mixed-function oxidases. The purpose is to produce a very susceptible SPWF due to disruption of two metabolic detoxification systems.

Bifenthrin or other pyrethroid
Piperonyl butoxide
Piperonyl butoxide + bifenthrin (or other pyrethroid)
Chlorpyrifos or other organophosphate
Piperonyl butoxide + chlorpyrifos
Piperonyl butoxide + bifenthrin (or other pyrethroid) + chlorpyrifos
Untreated check (UTC)
Untreated check block

C: Adjuvants to consider for inclusion with trial agents and for an actual adjuvant test of coverage efficacy (via use of dyes and image analysis etc).

Penetrator Plus (Helena)
Kinetic (Helena)
INDUCE pH (Helena)
Carboxymethcellulose (CSI)

Silwet L77 (Loveland Industries)
Triton B-1956 (Rohm and Haas)
Comate products (S. Helffrich and Associates, Inc.)

[1] Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may be suitable.

[2] Whole season rotational pesticide scheme "b." for natural enemy conservation suggested by Philip Stansly, Southwest Florida Research & Ed. Center, P.O. Drawer 5127, IFAS, Univ. FL, Immokalee, FL 33934

[3] Three-way tank mix for synergism suggested by Charles Silcox, Roussel Uclaf Corp.,Technical Center, 170 Beaver Brook Road. Lincoln Park, New Jersey 07035